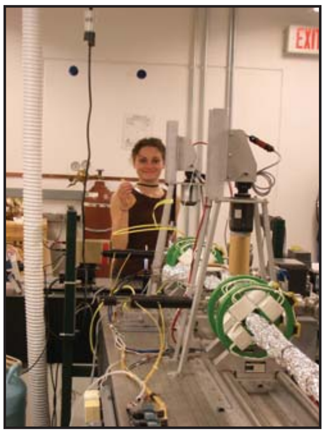
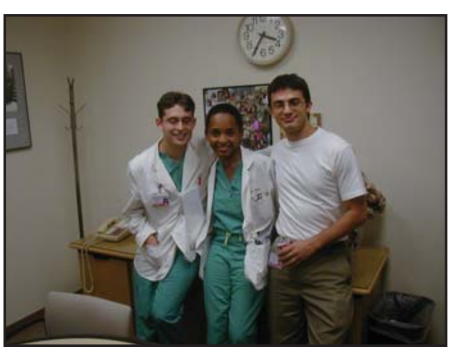
Office of Science

U.S. DEPARTMENT OF ENERGY

Program Guidebook



Science Undergraduate Laboratory Internship
(SULI)
Community College Institute of Science and Technology
(CCI)
Pre-Service Teachers Program
(PST)
Faculty and Student Teams
(FaST)



Department of Energy
Office of Science
Washington, DC 20585

Office of the Director

May 2005

Dear Colleagues:

Congratulations on your selection as a Department of Energy (DOE) Office of Science research intern. It is my pleasure and privilege to introduce you to one of the premier research organizations in the world, and to welcome you aboard.

The DOE Office of Science is the single largest supporter of basic research in the physical sciences in the U.S. We sponsor fundamental research programs in basic energy sciences, materials and chemical sciences, nanoscale science, climate change, genomics, life sciences, fusion energy sciences, high energy physics, nuclear physics and advanced scientific computing.

The DOE Office of Science supports a diverse portfolio of research at more than 275 colleges and universities nationwide. This year, we are funding the work of about 23,500 scientists, including more than 10, 000 Ph.D.s, graduate students and postdoctoral researchers at this nation's institutions of higher learning.

The Office of Science is the steward of 10 world-class laboratories with unmatched capabilities for solving complex interdisciplinary scientific problems, and we fund research at DOE's seven other national labs as well. The DOE national laboratory system is the most comprehensive research system of its kind in the world - and the backbone of American science.

The DOE Office of Science also builds and operates the world's finest suite of scientific facilities and instruments, used annually by more than 19,000 researchers to extend the frontiers of all areas of science.

In sum, the DOE Office of Science's mission is to deliver the remarkable discoveries and scientific tools that will transform our understanding of energy and matter and advance the energy, economic and national security of the United States.

The DOE Office of Science also has played a fundamental role in training America's scientists and engineers for more than 50 years. Today we offer a range of workforce development programs for teachers and scientists to offer opportunities for scientific discovery, and to ensure that this nation has the scientific workforce we will need in the twenty-first century.

That is why our Office of Workforce Development for Teachers and Scientists sponsors the Science Undergraduate Laboratory Internship (SULI), the Community College Institute of Science and Technology (CCI), Pre-Service Teachers Program (PST) and Faculty and Student Teams (FaST) - and why we are so pleased you are with us.

As President Bush has remarked, "Scientific and technological research are a high calling for any individual. And promoting research is an important role of our Federal government." I encourage you to take full advantage of your DOE internship and wish you every success as you pursue a career in science.

Sincerely,

Raymond L. Orbach

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PART 1: WELCOME AND EDUCATIONLINK

Congratulations on being selected as a research intern for the U. S. Department of Energy's (DOE) Office of Science (SC). The quality of your experience largely depends on you. If you take the initiative to learn all you can and positively contribute your thoughts, ideas, questions, and efforts to the research team you are working with, you will gain insight into how science is performed at your laboratory. If you have questions about your program, contact the DOE staff personnel listed in the back of this guidebook.

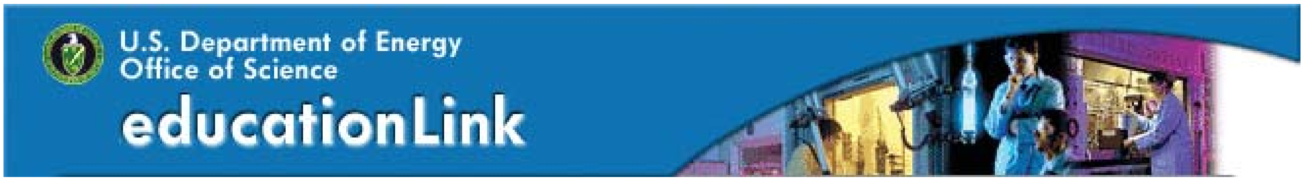
The purpose of this Program Guidebook is to assist you with the required deliverables of your research experience. Whether you are preparing an abstract of your research, a research paper, an oral presentation, an educational module, or a poster presentation, this guidebook will provide sample work by previous interns and formatting requirements to ensure that your research is presented in a consistent, professional manner. Your abstracts will be published in the DOE's *Journal of Undergraduate Research* (JUR) and it is important that you understand the formatting requirements for that publication. Outstanding research papers may be published and those students may have the chance to present their research at the American Association for the Advancement of Science (AAAS) annual meeting in mid-February.

Students may also elect to have their papers reviewed for publication in the *Journal of Young Investigators* (JYI). This is not a DOE-funded journal; it is a peer-reviewed publication for undergraduate research. More information about JYI is available at http://www.jyi.org. Your laboratory and DOE will conduct the first review of research papers from students who elect to have their papers reviewed for possible publication in the JUR. Papers not selected for publication in the JUR may be submitted to the JYI for their consideration.

The website that will serve as the center for program information and the place for submitting your required deliverables is called "Education Link" or "EduLink." The URL for this website is http://educationlink.labworks.org. To access the website, use the username and password that you created for your online application. If you are unsure of your username and password, you can request them by clicking on the link for "forgotten passwords." Some resources on the EduLink website are:

- Online lessons about security requirements, environmental awareness, safety regulations, and organizations that you need to know about as a DOE intern;
- A syllabus for the seminars, meetings, and tours that you may attend during your internship;
- Advice on submitting your required deliverables and a link to upload them;
- Links for surveys to provide feedback regarding your research experience;
- An electronic bulletin board to share ideas, concerns, and experiences; and
- Links for professional societies and job opportunities.

After you have completed your required deliverables, you will submit them to the DOE via the EduLink website. It is important to read this guidebook carefully to ensure that your required deliverables are in the proper format prior to submitting them. Your mentor and the education program staff at your laboratory will be available to assist you and to answer any questions that you may have regarding the format and content of your work.



Welcome to educationLink!

EducationLink is designed to provide resources, tools, and information about your fellowship, the history and mission of the DOE, and the roles and responsibilities of its laboratories, particularly in the domain of Environment, Safety, and Health (ES&H) and Security.

When you click on the link below, to access the site, a box will pop up asking for a user name and password. Please use the same user name and password that you chose when you created your applicationLink account.

A description of how to navigate through the site is found at the “Getting Started” link, available on every page. If you have any questions or cannot remember your user name or password, you can contact your Education Director or Program Administrator.

Enter educationLink!

Forgot your username or password?

Education Links

Office of Science Education Programs
Journal of Undergraduate Research (Volumes 1-4)
Other Federal Science Internship Programs
Education Web Sites at DOE Labs and Facilities
DOE Science Careers and Internships
DOE Science Pages for Kids / The Center for Excellence in Education
DOE Resources for Teachers and Students

Security & Privacy

educationLink
...using Pachelbel technology
Got a comment? Contact Cori Blake

Getting Started
Search
Bulletin Board
Syllabus
Resources
Surveys
Abstracts/Papers

We're glad you're here

Welcome to the U. S. Department of Energy (DOE) Office of Science's Laboratory Fellowships online course. We want you to make the most of your experience, so we have developed this online training course to better prepare you for your assignment. We have designed this web site to help you more clearly:

- Understand who DOE and the National Labs are
- Understand what DOE and the National Labs do
- Understand your role at the National Lab during your fellowship
- Understand what is expected of you during your fellowship
- Understand your mentor's responsibilities
- Learn about basic environment, safety & health regulations
- Learn about security regulations
- Learn about the DOE and how its missions have served the public's needs.

Please review these lessons:

- Your Internship
- Department of Energy
- Office of Science
- National Laboratories
- Env., Safety & Health
- Security

These are for your reference:

- Professional Societies
- Job Opportunities
- Other Technical Internships

You have been selected to participate in one of the following unique DOE-sponsored programs: Community College Institute of Science and Technology (CCI); Faculty and Student Teams Program (FaST); Pre-service Teacher Program (PST); or Science Undergraduate Laboratory Internships Program (SULI).

This page is: sys_content/home educationLink

REQUIRED DELIVERABLES FOR PROGRAM PARTICIPANTS

Required by all students from the following programs:

- **Science Undergraduate Laboratory Internships (SULI)**
- **Community College Institute (CCI)**
- **Pre-Service Teachers (PST)**
- **Faculty and Student Teams (FaST)**

1) Within your first week at the lab, complete the pre-survey posted on your eduLink account.
2) Write an abstract of your research for submission to the Journal of Undergraduate Research and upload the abstract via your educationLink account. Guidelines for submitting a research abstract are in Part 3 of this Program Guidebook.
3) As required by your lab, you must submit at least one of the following related to the research conducted during your internship: (1) A written research paper (required for all second term SULI students); (2) A copy of MS Power Point Slides used as part of an oral presentation; and/or (3) A copy of a poster or slides used to construct a poster used as part of a poster presentation. These required deliverables must be uploaded via your educationLink account. Guidelines for these deliverables are also provided in this Program Guidebook.
4) During your last week at the lab, complete the post-survey posted on your eduLink account.

For PST interns ONLY (as specified by your lab):

5) Prepare an Education Module that is inquiry-based, aligned with the National Science Education Standards (see http://www.nap.edu/html/nses/html), and based on your research. Upload this module via your eduLink account.

OR

6) Produce a journal, research notebook, or electronic portfolio that demonstrates your work and thinking regarding the implementation of your research work into a classroom setting. Upload this deliverable via your eduLink account.

PART 2: INFORMATION FOR MENTORS, MASTER TEACHERS, AND FACULTY TEAM MEMBERS

Mentors:

The U. S. Department of Energy appreciates the efforts made by its research scientists and engineers to mentor program interns. Good mentors serve not only as experts in their fields for these future scientists and engineers, but also as role models for lifelong learning and leadership in the scientific community. Thank you for your role in setting high standards for the next generation of researchers.

Mentors are primarily responsible for the safety of program participants in their labs. Please work with your lab education office to ensure that program participants receive the appropriate safety training for the work they will accomplish in your lab. An example of a safety contract, used by the Lawrence Berkeley National Laboratory, is shown on page 12.

Mentors are also responsible for reviewing all student work. Because all abstracts will be published in the *Journal of Undergraduate Research* (JUR), it is especially important that mentors review the abstracts for correctness and to ensure that no proprietary information or otherwise inappropriate material is included in the abstract. Please keep in mind, all abstracts and papers will list students and mentors as co-authors. All abstracts will be subject to one of two grading rubrics depending on the format of the research paper submitted (please see page 14 for the Abstract Rubric and page 15 for the Alternative Paper Format Abstract Rubric).

Mentors should also discuss with students whether or not their research paper should be reviewed for publication in the JUR. This is considered an internal DOE publication that should not preclude the student's work from being published in other journals. However, mentors should discuss this issue with their students and jointly decide if the student's research paper should be reviewed for the DOE journal.

Students whose papers are selected for publication in the JUR will be invited to attend the annual meeting of the American Association for the Advancement of Science (AAAS) in mid-February following their internship. Their abstracts will be published in the AAAS Meeting Program and the students will present a summary of their research at the Student Poster Award Competition.

Students may also elect to have their papers reviewed for publication in the *Journal of Young Investigators* (JYI). This is not a DOE-funded journal; it is a peer-reviewed publication for undergraduate research. More information about JYI is available at http://www.jyi.org. The laboratory and DOE will conduct the first review of research papers from students who elect to have their papers reviewed for possible publication in the JUR. Papers not selected for publication in the JUR may be submitted to the JYI for their consideration.

After mentors have reviewed the student's abstract and research paper or presentation material, **the student should print out a hard copy of the required deliverables (including the abstract) and include a signature by the student author and the mentor.** See the example (page 23) of where those signatures should be located on the sample title pages in this guidebook. This hard copy should be given to the laboratory education program manager to be kept on file.

Not all research lends itself to publication in the traditional research paper format such as papers on science policy, computer programming, or for students working with proprietary information that cannot be readily shared with the public. In these instances we have provided an Alternative Paper Format (see pages 17 and 39 for details).

Any questions regarding publications of student research work should be directed to the DOE Headquarters personnel listed at the end of this guidebook.

Master Teachers:

One of the goals for the PST program is to help Pre-Service Teachers become a part of the community of scientists. As scientific community members, teachers will be able to command greater respect from their students and will multiply the resources available to them in the classroom. Master teachers should work to help students understand the long-term benefits of establishing relationships with people at the laboratory and with the other science and mathematics teachers they meet during this summer experience.

Master teachers should visit their students in the laboratory setting to discuss their research with both the student and mentor scientist. Plan to work closely with your students in both the educational environment and lab settings to ensure your students get the maximum benefit from their research experience.

Discuss local, state, and national standards with your PST students and the importance of having a working knowledge of them. Important national documents include the American Association for the Advancement of Science (AAAS) Benchmarks (http://www.project2061.org/tools/benchol/bolintro.htm), National Research Council (NRC) – Science Education Standards (http://www.nap.edu/html/nses/html), and National Council for Teachers of Mathematics (NCTM) standards (http://standards.nctm.org). State standards in the states where the students hope to be employed or are currently attending school may also be useful to some students. Plan to discuss which standards students feel would be of most use to them as they begin their careers.

Many master teachers find it useful to model mini-lessons for their students based on the inquiry-based model of science teaching. Hands-on activities in which the students actually do the activities, has also proven successful especially for students who have not had much experience with inquiry-based teaching.

PST students will be working to perform research, transform their research experience into a classroom lesson, maintain a personal journal, and communicate their results in formal research papers and presentations. The master teacher is expected to assist students with each of these tasks and to provide encouragement and support when students feel overwhelmed.

Here are two books that you may choose to use as resources for helping your students think about their teaching and the challenges that await them during their first year in the classroom:

1. Banner, James M., and Cannon, Harold C. (1997). *The Elements of Teaching*. Yale University Press.
2. Palmer, Parker J. (1998). *The Courage To Teach*. Jossey-Bass, Inc.

FaST Faculty Team Members:

The DOE Laboratories provide a unique opportunity for faculty members to work as part of a team with students and DOE research scientists and engineers. It is important that the students on the FaST team look to the faculty member and the DOE mentor scientist not only for information and expertise, but also as role models for life-long learning and leadership in the scientific community. Thank you for your role in setting high standards for the next generation of researchers.

While this is a "team" effort, it is the responsibility of the faculty member of the FaST team to make sure that all student deliverables are submitted to educationLink at the proper time. Like the DOE mentor scientist, faculty team members are responsible for reviewing all student work. Because all abstracts will be published in the *Journal of Undergraduate Research* (JUR), it is especially important that faculty and DOE science mentors review abstracts for correctness and ensure that no proprietary information or otherwise inappropriate material is included in the abstract. All abstracts and papers should list students, faculty, and the DOE mentors as co-authors. All abstracts will be subject to one of two grading rubrics depending on the format of the research paper submitted. Please see page 14 for the Abstract Rubric and page 15 for the Alternative Paper Format Abstract Rubric.

Faculty team members and DOE mentor scientists should also discuss with students whether or not their research paper should be reviewed for publication in the JUR. This is considered an internal DOE publication that should not preclude the student's work from being published in other journals. However, faculty team members and mentor scientists should discuss this with their students and jointly decide if the team's research paper should be reviewed for publication in the JUR.

Students may also elect to have their papers reviewed for publication in the *Journal of Young Investigators* (JYI). This is not a DOE-funded journal; it is a peer-reviewed publication for undergraduate research. More information about JYI is available at http://www.jyi.org. The laboratory and DOE will conduct the first review of research papers from students who elect to have their papers reviewed for possible publication in the JUR. Papers not selected for publication in the JUR may be submitted to the JYI for their consideration.

After the student's mentor has reviewed the student's abstract and research paper or presentation material, **the student should print out a hard copy of the required deliverables (including the abstract) and include a signature by the student author, faculty team member, and the DOE science mentor.** See the example (page 23) of where those signatures should be located on the sample title pages in this guidebook. This hard copy should be given to the laboratory education program manager to be kept on file.

FaST Faculty Team Member Required Deliverables:

Each faculty member must be at the National Lab for the initial 10 week period with at least 1 student and not more than 3 students. The students must be from the same institution as the visiting faculty. It is expected that each FaST faculty will at sometime in their collaboration with the National Lab, submit a grant proposal to a granting institution, hopefully in partnership with the National Lab. It will be up to the respective National Labs to set the time limits for grant submittals.

The following is a minimum standard. Any participating Lab may increase the minimum requirements such as requiring a grant submittal at an earlier date or risk dismissal from the program.

Year 1

- Students submit abstract & research paper
- Faculty Member submits a short report via eduLink with copies to host lab's FaST Program Manager and Mentor Scientist that includes:
    - ♦ Summary of research project (not an abstract), including each student's specific role in the project
    - ♦ Benefits (or not) of research experience
    - ♦ How FaST experience transmits back to their college/university
    - ♦ Faculty member's research goals to begin developing a research grant proposal
    - ♦ Comments from mentor or lab education staff

Year 2

- Students submit abstract & research paper
- Faculty Member submits a short report via eduLink with copies to the lab's FaST Program Manager and Mentor Scientist that includes:
    - ♦ Summary of research project (not an abstract), including each student's specific role in the project. This should show progress from Year 1
    - ♦ Response from college/university of the team's year 1 experience
        - Did the FaST do any presentations at their college/university?
        - Faculty member submit a report to their Dean/Department chair
        - Did students receive any credit hours for their internship?
        - Increase in applicants from college/university to SULI, CCI, PST
        - Career choices of student members (change of major, graduate school, etc.)
    - ♦ Involvement of mentor & education staff
    - ♦ Some progress in development of research grant proposal

Year 3

- Students submit abstract & research paper
- Faculty Member submits a short report via eduLink with copies to the lab's FaST Program Manager and Mentor Scientist that includes:
    - ♦ Summary of research project (not an abstract), including each student's specific role in the project. This should show progress from Year 2
    - ♦ Response from college/university of the team's year 2 experience
        - ♦ Support for development of research grant proposal from Dean/Department Chair, President, etc.
        - ♦ Did the FaST do any presentations at their college/university?
        - ♦ Faculty member submit a report to their Dean/Department chair
        - ♦ Did students receive any credit hours for their internship?
        - ♦ Increase in applicants from college/university to SULI, CCI, PST
        - ♦ Career choices of student members (change of major, graduate school, etc.)
    - ♦ Involvement of mentor, education staff
    - ♦ Submission of research grant proposal

Sample Safety Contract

Center for Science and Engineering Education
Memorandum of Understanding

<u>Safety Responsibilities for CSEE Participants</u>

Safety is an overriding consideration for all work involving student participants at the Berkeley Lab. In addition to assuring the safety of student participants, the Berkeley Lab wants to instill in student participants an understanding of the safety requirements and processes they will encounter throughout their careers following graduation. Based on these considerations, the undersigned agree to the following safety arrangements:

1. The Student will follow all applicable Berkeley Lab safety requirements. In case of doubt, the Student will consult with the Mentor before proceeding.
2. The Mentor will identify all personal protective equipment the Student will require and will assure that such equipment is available to the Student, and that the student knows when and how to use it.
3. The Mentor will not assign any task to the Student until the Mentor has verified that the student has the knowledge, skills and physical ability to perform the task safely. At a minimum, this will involve an initial safety orientation to the Student's work area and work assignments by the Mentor.
4. Based on the work the Student will perform, the Mentor and the Student will complete a Job Hazard Questionnaire (JHQ) as soon as possible following completion of the New Employee Orientation (EHS 010). The Mentor and the CSEE Supervisor will confer concerning the completion of training identified on the JHQ.
5. Until required training identified through the JHQ process or otherwise is completed, the Student may perform corresponding tasks only under close supervision of the Mentor, i.e., with the full knowledge of the Mentor and while in the same room or area.
6. The Mentor will provide appropriate safety supervision for the Student throughout the Student's stay at the Berkeley Lab.
7. The Mentor may delegate safety supervision as needed to the following qualified Laboratory employees:

___________________________ ___________________________

___________________________ ___________________________

Student / Date	**Mentor / Date**	**CSEE Supervisor / Date**
____________________	____________________	____________________
....	....	....

PART 3: THE RESEARCH ABSTRACT

<u>Abstracts for Research</u> (see Abstracts for Alternative Paper Format on the next page)

The abstract provides a brief overview of your entire research in no more than 2500 characters, including spaces, arranged in a single paragraph. The abstract briefly states the research problem or purpose of the research (Introduction), how the problem was studied (Methods), what was discovered (Results), and how the results might be interpreted (Discussion and Conclusions). Acronyms may be used in an abstract, however they should be spelled out the first time they are used. The abstract should stand alone and **NOT** include citations or references within the abstract itself. The names of the participant and the DOE mentor should be given in all capital letters.

While it is difficult to be both concise and descriptive, that is exactly what an abstract must do. The abstract should be written or updated after the participant's research is completed to ensure that it accurately and fully reflects the participant's work. If the abstract is not updated after the participant's experience is completed, the abstract score may not fully reflect the accomplished research.

Below is a sample abstract that demonstrates the characteristics of a good research abstract. The header is in black, the introduction is in blue, followed by the methods in red, followed by the results in blue, and ending with the conclusions in red. (**This is single-spaced here to save room -- in your paper, the abstract should be double spaced**).

Pharmacodynamic Responses of Target Tissues Exposed to Various Concentrations of the Organophosphate Insecticide Diazinon in Rats. JOE STUDENT (Somewhere College, Somewhere, FL 33333) IMA SCIENTIST (National Renewable Energy Laboratory, Golden, CO 80401).

Diazinon is a thionophosphate pesticide that, when metabolized into its oxon, competitively inhibits cholinesterases. In order to develop a physiologically based pharmacokinetic and pharmacodynamic (PBPK/PD) model for the organophosphate insecticide diazinon (DZN) in rats, a quantitative investigation of the pharmacodynamic response associated with acetyl-cholinesterase inhibition in targeted tissues of the body, namely the brain, blood, and diaphragm, is needed. Using a spectrophotometric assay, the extent of esterase inhibition following orally administered diazinon in corn oil at doses of 100 mg and 50 mg DZN/kg body weight over a 24-hour time course provides insight to the inhibition and recovery of acetyl-and butyrylcholinesterases in vivo. When comparing the 50 mg and 100 mg DZN/kg body weight time course of each tissue, little difference was seen between the degree of inhibition at each dose. This was consistent with the plasma, red blood cells (RBCs), brain, and diaphragm. The extent of inhibition followed the pattern of plasma>RBCs>diaphragm>brain. This was expected due to the method of dosing, and anticipated distribution of diazinon determined by blood flow, partitioning, and concentration of cholinesterases in the tissue. This work is a small portion of a much larger project being researched to develop a PBPK/PD model for diazinon in the rat, as well as investigate PBPK/PD model interactions for organophosphate insecticides in rats and humans.

The following research abstract is an example of an abstract that does **NOT** meet the requirements for a research abstract. Note that, among other problems, this abstract is more of just an introductory paragraph for the participant's research and uses acronyms that are not first defined (**This is single-spaced here to save room -- in your paper, the abstract should be double spaced**):

Identification of Biochemical Pathways using PNR. JOE STUDENT (Somewhere College, Somewhere, FL 33333) IMA SCIENTIST (National Renewable Energy Laboratory, Golden, CO 80401).

A computational model has been developed which accurately depicts pathways of enzyme-catalyzed reactions as specialized graphs. This graphical model is a first step toward a goal of manipulation and study of a biochemical system. PNR's of biochemical reactions are specific and detailed. In modeling biochemical pathways with a PNR places represent an organic chemical species, transitions represent and a chemical event. Minimal cycles, within the PNR, identify where flux conservation is being achieved. Understanding the Flux of a system can lead to the manipulation of feedback; thereby controlling the overall productivity of the system.

Abstract Evaluation Rubric

The following rubric will be used to evaluate abstracts submitted by program participants.

Abstracts assigned 0 - 5 points based on:

- (1 pt) Proper spelling, grammar, complete sentences, readability
- (1 pt) Well written introduction
- (1 pt) Methods are discussed
- (1 pt) Results are summarized
- (1 pt) Conclusions are presented

Abstracts for Alternative Papers

The Alternative Paper Format is **only** for program participants who meet one or both of the following criteria:

(1) Students are writing a paper on a science topic that does not fit into a research paper format that includes results and result analysis (for example, papers on science policy or computer programming)

(2) Students are working with proprietary information and cannot readily share their results with the public

The abstract for alternative papers is similar to the research abstract in that it summarizes your work in no more than 2500 characters including spaces, arranged in a single paragraph. The abstract should briefly state the subject of investigation or project (Introduction), provide a summary of resources used in your investigation or project (References), provide an interpretation of what you accomplished in you investigation or project relative to other similar projects (Comparison/Interpretation of Study), and discuss the aspects of your investigation or project that make it unique (Discussion). Otherwise, the format and content for these Alternative Paper Format abstracts should be the same as for the research abstract.

Alternative Paper Format Abstract Rubric

The following rubric will be used to evaluate Abstracts for papers following the Alternative Paper Format:

- (1 pt) Proper spelling, grammar, complete sentences, readability
- (1 pt) Well written introduction
- (1 pt) Reference Materials Summary
- (1 pt) Comparison/Interpretation of Study
- (1 pt) Discussion

PART 4: THE RESEARCH PAPER

Research Paper Format (see page 19 for Alternative Paper Format):

The main body (Introduction, Methods and Materials, Results and Discussion) of the research paper should be no longer than 10 pages. The Title Page, Table of Contents, Abstract, Literature Cited, Acknowledgments and any tables and figures are **not** part of the ten-page limit. An electronic copy of your paper should be uploaded to the DOE via your EduLink account, and you should also submit a hard copy to your mentor and your laboratory education program manager before the end of your internship.

The research paper must use the following specifications:

Margins:	**1 inch for all margins**
Font:	**Times New Roman or a similar font**
Font size:	**12**
Spacing:	**Double spaced**
Word Processor:	**MS Word, WordPerfect, LaTex, or PDF file**
Columns:	**One column**

The paper must include the following sections:

Title Page

(See sample, page 25)

Table of Contents

This section lists all parts and page numbers for the paper, including tables and figures.

Abstract

(See sample, Part 3 of this Program Guidebook)

Introduction/Problem Description

The introduction provides a rationale for the study, clearly states the nature and scope of the problem being investigated, and introduces the study by providing background information and a review of relevant literature. Your literature citations must follow IEEE (Institute of Electrical and Electronics Engineers) format for citations.

Materials and Methods
This section presents, in paragraph format, the materials and procedures used to conduct the research. A numbered list of steps is not appropriate. Instead, describe the research that was conducted, the equipment that was used, and the procedures that were followed. Assume the reader is knowledgeable in the field. Do not describe routine techniques that are already well known. Cite other publications for less well known but lengthy technical procedures.

Results
This section presents, in paragraph format, the data in an organized, refined fashion. Whenever appropriate, create tables and figures that illustrate the data. Do not interpret the results in this section, just describe the findings. Refer to all tables as "Tables" and to all graphs, photographs, or other illustrations as "Figures." List statistical operations where appropriate, e.g., "ANOVA" or "Student t-Test". At the bottom of each figure or table must be a complete but concise caption with an explanation of the data including any relevant statistical information, such as confidence limits, that might not be directly shown on the figure. Tables and figures should be included at the end of the paper and NOT included within the text of the paper.

Discussion and Conclusion
This section describes your interpretation of the research results**,** relates the results to the original purpose of the study, compares the findings with other existing research, and discusses whether your findings agree with other researchers' results and interpretations. Because conclusions are drawn from findings presented in the results section, you should refer to the specific data that support your conclusions. Also include plans for further research that directly relates to your work.

Literature Cited
When information or an idea is taken from another source or referred to directly or indirectly, it must be cited in the text and the origin of the information listed in this section (similar to a bibliography). Citations must be in IEEE format. For some examples of citations of IEEE format or instruction in using this format if you are unfamiliar with IEEE format, please see:

http://www.ecf.utoronto.ca/~writing/handbook-docum1b.html

http://www.class.uidaho.edu/adv_tech_wrt/resources/sources/bibliographic_ieee_format.htm

http://www.computer.org/cspress/instruct.htm

Acknowledgments
In this paragraph, mention where and when the research was accomplished and acknowledge the people who provided major assistance with your research. Acknowledge the U. S. Department of Energy, Office of Science and your host lab for creating, organizing, and funding the program. Also, if your internship has been partially sponsored by the National Science Foundation, thank the NSF for their help in the funding the program.

For examples of previously published papers visit:

http://www.scied.science.doe.gov/scied/JUR.html

Alternative Paper Format:

The Alternative Paper Format is only for students who meet one of the following criteria:

(1) Students are writing a paper on a science topic that does not fit into a research paper format that includes results and result analysis (for example, papers on science policy or computer programming).

(2) Students are working with proprietary information and cannot readily share their results with the public.

Students should keep in mind that the Alternative Paper Format still requires an abstract, which must be submitted by all students. However, students submitting a paper using the alternative paper format should carefully review the abstract prior to publication to ensure that the abstract does not include any proprietary information. In all cases, students should have their mentors review and approve their abstracts.

The main body of the Alternative Paper should be no longer than 10 pages. The Title Page, Abstract, Author Biography, Table of Contents, Literature Cited, Acknowledgements and any tables and figures are **not** part of the ten page limit. Literature citations must follow IEEE format. An electronic copy of your paper must be submitted to the DOE online via the EduLink website, and you should also submit a hard copy to your mentor and your laboratory education program manager before the end of your internship.

The Alternative Paper must use the following specifications:

Margins:	**1 inch for all margins**
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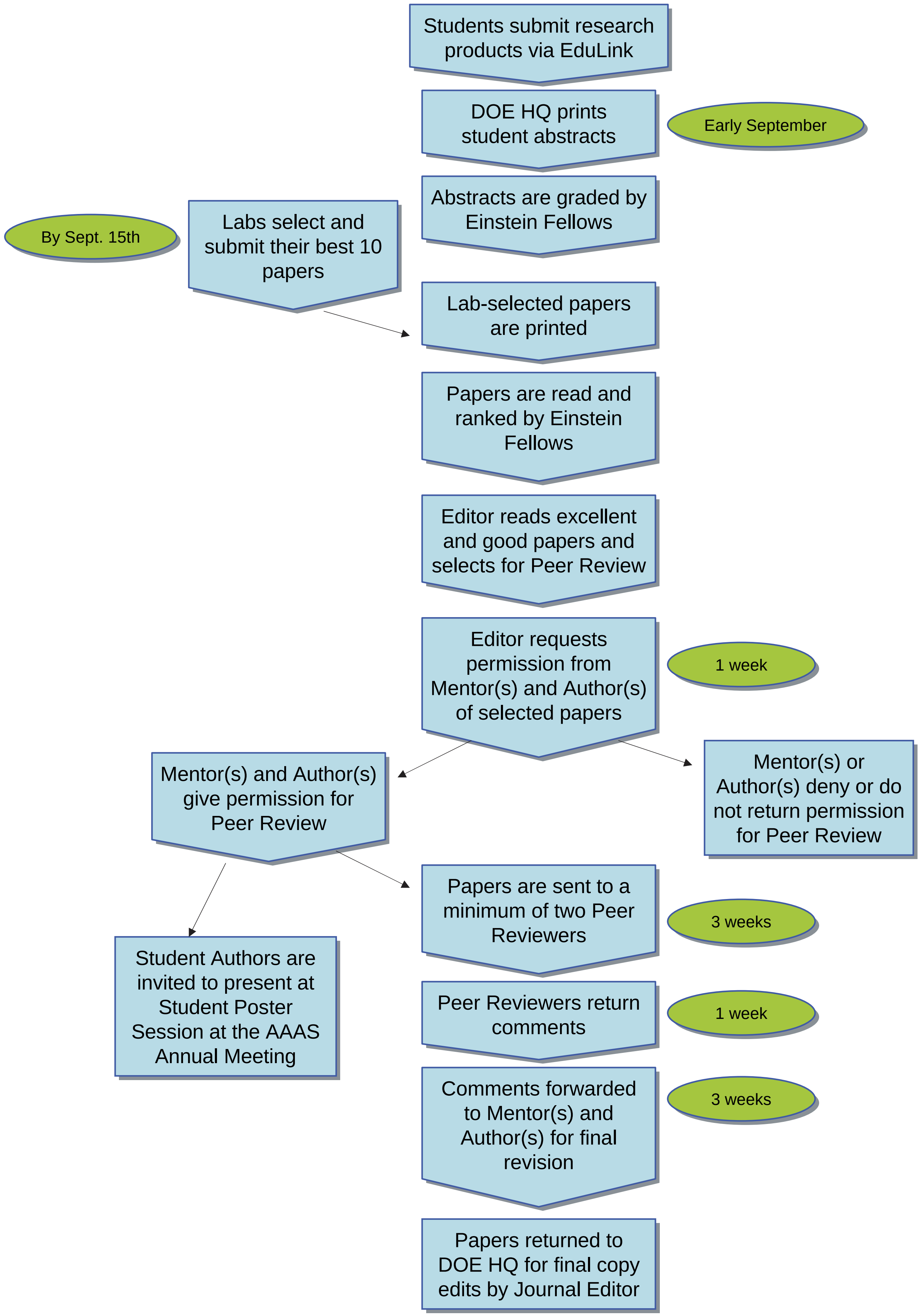
Spacing:	**Double spaced**
Word Processor:	**MS Word, WordPerfect, LaTex, or PDF file**
Columns:	**One column**

General Description: The Alternative Paper is a review article format, much like that seen in *Scientific American* articles. In initial paragraphs of the paper, the relevance and the importance of the subject matter should be made clear. In the first section (approx. 500 words), the author should lay a solid foundation of what is known in the field. The body of the paper should address the research and/or project work accomplished by the student. The latter portion of the paper should try to bring together any controversies and point to future experiments. Alternative Papers must include the following:

1. **Title Page** (Sample enclosed, see page 25)
2. **Abstract** (Sample enclosed, see Part 3 of this Program Guidebook)
3. **Body of Paper**
4. **Literature Cited (see Literature Cited in The Research Paper section)**
5. **Acknowledgements**
6. **Figures and Tables**

Process for Reviewing and Selecting Papers for the Journal of Undergraduate Research



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These are the guidelines that you should follow only if you are requested to submit your paper for inclusion in the Journal of Undergraduate Research (JUR). These guidelines apply to both research papers and alternative format papers. These guidelines are meant for the final step, after the papers have gone through the peer review process and you have made all the necessary changes. The guidelines below need to be specific for any paper that is to be published because of the strict requirements of the CMYK (cyan, magenta, yellow, black) printing process and the high resolutions needed for quality glossy publications such as the JUR. See the last paragraphs of these guidelines for more details about image formats and the CMYK printing process.

Basic Paper Formatting:

Your paper must follow the guidelines for publication as explained in this Program Guidebook (also online at http://educationlink.labworks.org/media/guidebook.pdf), including the proper use of IEEE format for the bibliography.

All papers will be reformatted during layout with a common font, size, columns, margins, etc. Please deliver a paper that is as straightforward as possible for translation into our final format. This includes using Word or another standard software package and not using any unusual characters (Times or symbol fonts only. If it is necessary to use an unsupported special character, you will need to submit the font file as well).

The final format will be a two column paper, very similar to the previous versions of the Journal which you can review online (http://www.scied.science.doe.gov/scied/JUR.html). It is also recommended that you look through professional journals (such as *Science*) to better understand how these papers are different than term papers.

Equations:

Some equations belong inline with the text. If your equation should stand alone in the paper, you may use equation editor in Word or a similar program to generate the equation and paste it into the Word document. If you are providing it as a separate file, please make sure it is in a Vector and text based format, not a bitmap picture. If it does not fit inline, then the equation must be referenced in the body of the paper.

Captions:

All visuals (i.e., tables, figures, pictures, drawings) need to have appropriate captions. These should be provided as standard text and numbered (e.g., Figure 3 , Table 2, etc.). All visuals will appear within the body of the paper (not at the end) and all captions will appear below their corresponding visual.

Visuals:

Visuals fall in several categories with different specifications, as specified below. See the separate section explaining Vector Graphics and RGB vs. CMYK if you are unfamiliar with these graphics issues. The Journal will be in two column format, meaning the standard visual will be about 3 5/8” wide. When appropriate, images may be smaller or larger. Please keep this in mind as you prepare your graphics. They must be clear and readable. This means color choices and resolution and text size must be appropriate. All visuals should be submitted as individual files and not embedded in a document.

Clustered Visuals:

When you have data that is best expressed in a series of images or graphs, you need to make sure that all the graphs are consistent in size, axis scale, and all other formatting. When appropriate, a single caption can explain a cluster (e.g. Figure 3a, 3b, 3c).

Tables:

Use Tables sparingly. We do not want to include “data dumps” in the journal. The data should be a refinement or raw data and both well organized and labeled. Proper units should be included. The inclusion of a data set (or partial data set) should advance the reader’s understanding of the research and should be referenced in the paper. Tables should be sized appropriately, and may be placed in a single column, or spanning both columns in the journal. Please provide an editable but formatted table in your Word document or as a separate file when appropriate.

Graphs and Charts:

Please be sure to include original files with your submission. Clipboard copies and/or embedded images are often difficult or impossible to use. If you are using a software package that is less common, please export the image as a vector based file and include the file in your submission. Graphs and charts should be vector based files. Please look at similar scientific journals (such as Science) for examples of how graphs are included. Notice that they often take up a small amount of space and so they need to be presented efficiently. This means that Excel graphs (which by default make the legend almost as big as the graph) need to be reworked. Additionally, the fonts used for labels should be sized appropriately for the small size. Please keep all backgrounds transparent unless you have a reason to do otherwise. A standard graph will be 3 5/8” wide (one column). All work should be done in CMYK whenever possible. Black text and lines need to be defined as true black (K). Excel and other programs do not have this adjustment, but with the original files the transformation can be made later.

Drawings:

Please use a vector based drawing program for any drawings that you submit. Adobe Illustrator is best. Word’s drawing tools are adequate, but make sure all objects are properly grouped. Do not use a program such as Paint. It does not have the proper resolution or editing options. All color drawings should be done in CMYK format. Black must be true black (not the RGB approximation).

Screen Captures:

Screen Captures should be done only when necessary, and should be done at the highest resolution possible. Images of screens should be trimmed to include only what is important for the reader to see (cropping, menu bars, etc.) where appropriate. Captured images should be saved directly as an image file and not incorporated into a Word or other document. These screen captures, by their nature, will be RGB and should be converted to CMYK with the additional step of all lines/text that appear black must be converted to true black (K).

Photos:

Any picture taken with a camera or scanner should be preserved and delivered in the highest resolution possible. If possible, the image should be in an uncompressed format (such as .tiff). jpeg images have a habit of blurring sharp lines and text, and repeated saving of the file causes a compounding of the compression errors. Resolution must be at least 300 dpi and the image size should be appropriate to the expected final layout size. Usually this is 3 5/8" (one column) wide.

File formats:

The preferred formats for visuals is Adobe Photoshop (.psd), Adobe Illustrator (.ai), .tiff, .eps , .emf . All files should be in CMYK mode with a resolution of 300 dpi. Avoid using the windows clipboard unless you really know what you are doing. The clipboard copies objects at screen resolution (72 dpi RGB).

Vector vs. Raster (or bitmap) images explained:

Many of us who have used a modern font understand that as the font is scaled up in a word processing program like MS Word, the curves get more detailed and the choppiness decreases. You may also have noticed that the choppiness you see on your screen (72 dpi) is not present when you print it (300 or 600 dpi). This is possible because modern fonts are built in vector format. The simplest example is a line. It is defined by two points in a vector file, but as a string of dots in a bitmap. As you zoom in on that line, the bitmap version shows its dots, while the vector continues to be a line. Additionally, a vector based graphic keeps every line and letter as a separate object. This is critically important when we need to correct color problems. We can apply a change to a single element and be sure that the entire object is converted properly. Bitmaps (including tiffs and compressed bitmaps like jpegs) are flat images with different colors mixed together and pixilated. Software can sometimes separate different colors, but never with 100% accuracy or with the ability to maintain sharp boundaries between objects. Photos should be bitmaps. Drawn objects (including graphs) should be vectors.

CMYK vs. RGB explained:

A computer monitor uses red, green and blue light to create all colors that you see (look with a magnifying glass, or look at your low resolution television). Every color is defined as a clustering of different amounts of each color of light. Yellow is obtained by mixing red and green, black is obtained by leaving all colors off, etc. When we print, those screen colors must be approximated by ink that works by laying down different levels of dark rather than different levels of light. The dots of color (cyan, magenta, yellow, and black) are placed very close together in different darknesses to create the colors that we want in the printout. The conversion process from RGB to CMYK can cause many colors to come out of the printer slightly different than what we see on the screen. This isn't bad unless the color is critical (skin tones) or detailed. The biggest problem is thin black lines. A black line on the screen (R=0, G=0, B=0) is converted to a line on paper (C= 20, M=33, Y=15, B=83) in some approximate way that looks black-ish. The problem is that for a thin black line, the C,M,Y that you find mixed in, will often show up clearly around the edges. Most people have experienced this with their inkjet printers from time to time, especially when printing text that isn't printed as true black and especially when the print heads are misaligned.

To maintain the quality of a publication such as the Journal of Undergraduate Research, we must go into every file and convert each black line from an RGB value to a CMYK value of (C=0, M=0, Y=0, K=100) in order to have a true black line. Similarly with text that is embedded in an image or graph. This problem is manageable to fix with vector based drawings, but is very difficult with pixilated drawings and impossible with compressed image formats.

Problems:

If any of the graphics come to us in a format that we cannot work with, we may be contacting you for a different version or asking you to clean up the images for us. Most submissions require at least one or two communications with the authors. Please contact us with any further questions or concerns. Proper submission format is necessary for your article to be printed. It may be necessary to reject a paper if the authors are not able to provide visuals of a suitable quality.

<SAMPLE TITLE PAGE>

Analysis of the Characteristics of the Electron Cloud Build-Up in High Energy Particle AcceleratorsUsing the Java Programming Language

Laura Loiacono

Office of Science, SULI Program

Loyola University Chicago

Argonne National Laboratory

Argonne, Illinois

August 2, 2002

Prepared in partial fulfillment of the requirements of the Office of Science, U.S. Department of Energy Science Undergraduate Laboratory Internship (SULI) Program under the direction of Dr. Katherine Harkay in the Accelerator Systems Division of the Advanced Photon Source (APS) at Argonne National Laboratory.

Participant: ____
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Research Advisor: ____
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COMPLETE SAMPLE RESEARCH PAPER

Increasing Efficiency in Photoelectrochemical Hydrogen Production

Scott Warren

Office of Science, Science Undergraduate Laboratory Internship (SULI)

Whitman College

National Renewable Energy Laboratory

Golden, Colorado

July 27, 2001

Prepared in partial fulfillment of the requirements of the Office of Science, Department of Energy's Science Undergraduate Laboratory Internship under the direction of J. Turner in the Basic Sciences Division at National Renewable Energy Laboratory.

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Research Advisor: ______________________________
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ABSTRACT

Increasing Efficiency in Photoelectrochemical Hydrogen Production. SCOTT WARREN (Whitman College, Walla Walla, WA 99362) JOHN TURNER (National Renewable Energy Laboratory, Golden, CO 80401).

Photoelectrochemical hydrogen production promises to be a renewable, clean, and efficient way of storing the sun's energy for use in hydrogen-powered fuel cells. We use p-type $Ga_{.51}In_{.49}P$ semiconductor (henceforth as $GaInP_2$) to absorb solar energy and produce a photocurrent. When the semiconductor is immersed in water, the photocurrent can break down water into hydrogen and oxygen. However, before the $GaInP_2$ can produce hydrogen and oxygen, the conduction band and the Fermi level of the semiconductor must overlap the water redox potentials. In an unmodified system, the conduction band and Fermi level of $GaInP_2$ do not overlap the water redox potentials. When light shines on the semiconductor, electrons build up on the surface, shifting the bandedges and Fermi level further away from overlap of the water redox potentials. We report on surface treatments with metallated porphyrins and transition metals that suppress bandedge migration and allow bandedge overlap to occur. Coating ruthenium octaethylporphyrin carbonyl (RuOEP CO) on the $GaInP_2$ surface shifted bandedges in the positive direction by 270 mV on average, allowing the bandedges to frequently overlap the water redox potentials. Coating the $GaInP_2$ surface with $RuCl_3$ catalyzed charge transfer from the semiconductor to the water, lessening bandedge migration under light irradiation. Future work will focus on the long-term surface stability of these new treatments and quantitative applications of porphyrins.

INTRODUCTION

Current methods of energy production have substantial limitations. The pervasive use of fossil fuels creates large amounts of pollution and poses a threat to both human and ecosystem health. As demonstrated by recent fluctuations in energy prices, the United States has little control over significant portions of its energy supply. Hydrogen fuel is a leading contender to solve these energy problems.

Our work focuses on devising a domestic, renewable, and nonpolluting system for producing hydrogen. The hydrogen-production system consists of a semiconductor working electrode and a platinum counter electrode immersed in an aqueous electrolyte. When the semiconductor is irradiated with light more energetic than its bandgap, electrons in the valence band are excited into the conduction band. The excited electrons generate a photocurrent, splitting water into hydrogen at the semiconductor surface and oxygen at the platinum electrode surface.

For direct photoelectrochemical decomposition of water to occur, the hydrogen-production system must meet several requirements. First, the distance between the conduction band and the Fermi level of the semiconductor must be larger than the redox potential of water. At 25 ºC, the redox potential of water is 1.23 eV. A cathodic overpotential of 24 meV and an anodic overpotential of 96 meV are typical values for water electrolysis at a photocurrent of 20 mA/cm^2 [1]. Therefore, water has an effective redox potential of 1.3-1.4 eV. The semiconductor must have a bandgap of at least 1.5 eV to split water.

Second, the semiconductor bandedges must overlap the conduction band and the Fermi level. The semiconductor’s conduction band must be higher in energy than the water reduction potential so that the reduction of water will be energetically favorable. Similarly, the semiconductor’s Fermi level must be lower in energy than the water oxidation potential so that the oxidation of water will be energetically favorable.

Third, charge transfer from the semiconductor surface to the water must occur quickly. If electrons build up on the surface of the semiconductor, they will shift the bandedges and Fermi level in a negative direction. Additionally, charge build-up on the semiconductor surface can destabilize the surface and allow the semiconductor to decay. Methods have been devised to partially catalyze charge transfer [2].

Finally, the semiconductor must be stable during photoelectrolysis conditions in water. Inert semiconductors – such as TiO_2, $KTaO_2$, ZrO_2, and SiC – have too large a bandgap to collect a significant portion of the solar spectrum. Unfortunately, many semiconductors with smaller bandgaps are unstable under photoelectrolysis conditions. Recently, $GaInP_2$ was identified as one of the few semiconductors with an ideal bandgap that is moderately stable during photoelectrolysis [3].

P-type $GaInP_2$ has a bandgap of 1.8-1.9 eV, ideal for splitting water [4]. However, the conduction band and Fermi level are 300-450 meV too negative to overlap the water redox potentials when overpotentials are taken into account. Additionally, $GaInP_2$ does not catalyze charge transfer well. This research focuses on correcting these problems by modifying the inner Helmholtz layer. Previous research has shown that adsorbing organic molecules onto the $GaInP_2$ surface can shift bandedges [5], while adsorbing transition metals (particularly Ru and Rh) can partially catalyze charge transfer [2]. With the hope of combining these effects, we studied a wide range of metallated porphyrins.

In this paper, we report on our results using capacitance-voltage and current-voltage measurements. We performed kinetics studies to determine charge catalysis on those porphyrins that succeeded in shifting band edges in the positive direction. We also combined porphyrin treatments with transition metals to bolster charge transfer kinetics.

MATERIALS AND METHODS

We used all chemicals as received. The chemicals included H_2SO_4 (J. T. Baker), HNO_3 (J. T. Baker) and dichloroethane (DCE) (Aldrich). The porphyrins used in this study were manufactured by Midcentury and are listed in Table 1. All porphyrins were made to 0.1 mM in DCE. Phthalate buffer and carbonate buffer (pH 4 and 10) (Beckman), Hydrion buffers (pH 2 - 12) (Metrepak) and dilute sulfuric acid were the electrolytes in our three-electrode cell. A 0.010 M $RuCl_3$ (Strem) solution in pH 1.5 HCl was used from a previous study [2]. We also used a platinum sol (colloid size ranging from 50 - 100 Å) made by refluxing hydrogen hexachloroplatinate hydrate (Aldrich) with citric acid.

Our materials included zinc-doped 3 μm thick p-type $Ga_{.51}In_{.49}P$ epilayers (henceforth, $GaInP_2$). It was grown by atmospheric-pressure metal organic chemical vapor deposition (MOCVD) epitaxy on zinc-doped GaAs substrates approximately 350 μm thick and misoriented from the (100) surface by 2° toward (110). A growth temperature of 700 °C and growth rate of 4.4 μm/h were used [6]. The carrier concentration in the sulfuric acid-etched $GaInP_2$ layer was (5-7) x 10^{16} cm^{-3}. Electrodes were made from the $GaInP_2$ using a previously published technique [2]. Exposed surfaces of the electrodes ranged from 0.02 to 0.13 cm^2. Prior to use, the electrode was etched in concentrated sulfuric acid, rinsed in deionized water, and dried in nitrogen gas. After drying, the electrode surface was chemically modified using the methods discussed below: porphyrin drop evaporation, porphyrin spray application, and metal-ion dip-coating.

Using the porphyrin drop evaporation method, we placed a 50 μL drop of the 0.1 mM porphyrin solution in DCE on the surface of the $GaInP_2$ electrode. The DCE evaporated under a stream of nitrogen gas, leaving a layer of the porphyrin on the electrode surface.

In the porphyrin spray application, we used a chromatography sprayer to apply 0.1 mM porphyrin solutions in DCE to the surface of the $GaInP_2$ electrode. The spraying occurred in half-second pulses to allow the DCE to evaporate before spraying again. The spray time ranged from 5 to 80 seconds.

We performed metal-ion chemisorption using a previously published method [2]. Electrodes were immersed in the $RuCl_3$ solution for 60 seconds and in the Pt sol for 1 - 3 hours. In combination treatments of porphyrins with metal ions, the metal ion was adsorbed first. Then, a layer of the porphyrin was adsorbed.

Capacitance-voltage (C-V) and current-voltage (I-V) measurements were performed in a three-electrode cell. The setup consisted of a $GaInP_2$ semiconductor, a platinum mesh counter electrode (~2 cm^2) and a saturated calomel reference electrode (SCE). We irradiated the $GaInP_2$ electrode with a Cole-Parmer 41500-50 Fiber Optic Illuminator housing a 150 W quartz halogen bulb. Data were collected using a Solartron 1286 Electrochemical Interface connected to a Solartron SI 1260 Impedance/Gain-Phase Analyzer. We used ZPlot 2 and ZView 2 software to collect and analyze C-V data and CorrWare 2 and CorrView to collect and analyze I-V data. Measurements were made at a frequency of 10 kHz with a 10 mV rms amplitude. Scan rates ranged from 5 to 10 mV/s. For measurements in the dark, data was collected between –1.0 V and +0.2 V vs. SCE and the current range was automatically selected by ZPlot. For measurements in the light, the negative end of the scan range extended to –2.2 V vs. SCE and the current range was fixed at 0.2 or 2.0 mA, depending on the photocurrent.

In agreement with a previous study, we successfully modeled the $GaInP_2$/water system as a series RC circuit [7]. In this model, R_s is the series resistance of the circuit and C_{sc} is the capacitance of the space charge region (see Figure 1). By modeling the space charge layer of the semiconductor in this manner, we were able to determine the flatband potential using Mott-Schottky plots.

RESULTS

Table 1 displays the flatband potentials for drop-evaporated porphyrin treatments and drop-evaporated porphyrins combined with transition metals. The porphyrins were drop-evaporated onto a new $GaInP_2$ electrode after initial characterization and etching with concentrated sulfuric acid. The testing was done in pH 4 buffer. Repeated scans were performed in the cathodic and anodic directions to determine the stability of the surface treatment. The results in Table 1 are the average of all of the scans in both cathodic and anodic directions. All of the porphyrins show a statistically significant shift in flatband potentials, with the ruthenated porphyrins showing the greatest shift. The bandedges shifted into overlap conditions about 20% of the time with the RuOEP CO treatment. Both of the combination treatments of RuOEP CO with either Pt sol or $RuCl_3$ showed substantial shifts in bandedge position. These combination treatments allowed overlap of the water redox potentials to occur in the dark

Figures 2 and 3 show the results of charge transfer catalysis testing in pH 4 buffer. The porphyrins were applied to new electrodes. At higher light intensities, the potential scan range was shifted negative as the flatband potential shifted negative. Of the molecules tested, only the RuOEP CO shifted the conduction band and Fermi level into the correct positions under light irradiation.

Figure 4 demonstrates the effect of a combined porphyrin-metal ion treatment. Dip-coating a RuOEP CO-treated electrode with $RuCl_3$ vastly improves charge catalysis properties up to a photocurrent of 1 mA/cm^2. Testing is in pH 4 buffer.

Figure 5 compares the drop-evaporation method with the spray application method. The drop-evaporation method is capable of adsorbing greater amounts of porphyrins on the $GaInP_2$ surface than the spray application method.

Displayed in Figure 6 are the effects of testing in a range of pHs on a treated and untreated electrode. The most substantial shift in flatband potential occurs at pH 4, hence the testing at that pH.

Figure 7 shows the possible desorption of CoTPP in pH 4 buffer over a period of days. The flatband potential decreases by 50 mV after 23 hours and by another 25 mV after another 70 hours.

Table 2 shows the doping densities in an untreated electrode (and hole concentrations in a treated electrode). The combination metal-RuOEP CO treatments show a statistically significant decrease in doping density as compared with untreated electrodes.

DISCUSSION AND CONCLUSION

In order to photoelectrochemically split water into hydrogen and oxygen, the conduction bandedge must be higher in energy than the water reduction potential and the Fermi level must be lower in energy than the water oxidation potential. Our survey of porphyrins as bandedge-shifting agents showed that RuOEP CO shifts bandedges a substantial amount in the correct direction. When combining the RuOEP CO with a transition metal, such as ruthenium or platinum, the bandedge shift increases.

The large standard deviation in the flatband potential is caused by two factors. The first is the varying application thickness. As we increase the porphyrin application thickness on the $GaInP_2$ surface, the shift in flatband potential increases (see Figure 5). With the RuOEP CO drop-evaporation treatment, the flatband potential shifted as much as 600 mV when a large amount of porphyrin was applied to an electrode with a small surface area. Conversely, the flatband potential shifted as little as 100 mV when a small amount of porphyrin was drop-evaporated onto a larger surface area. The RuOEP spray application applied only minute amounts of the porphyrin to the electrode surface, causing only slight shifts in flatband potentials. The flatband potential shifted as little as 26 mV when we sprayed the electrode for 5 seconds, and as much as 90 mV when we sprayed the electrode for 80 seconds.

The second factor causing a large standard deviation in the flatband potential is the electrode age. After several etchings in concentrated sulfuric acid, the response to porphyrin treatments decays. We hypothesize that the decrease in response is due to the decrease in surface defects (and an increase in the surface smoothness) of the $GaInP_2$ as the electrode is etched more. A previous study showed that the photoluminescence of $GaInP_2$ increases as the etch time increases [5]. In fact, the photoluminescence increases the fastest when etched in concentrated sulfuric acid, as compared with the other etchants studied. The increase in photoluminescence is indicative of fewer surface states, suggesting that the $GaInP_2$ has a cleaner surface with fewer defects. As the number of surface states and defects decrease, there is less opportunity for the porphyrin to attach to the surface. Thus, with less porphyrin attached to the surface, the bandedge shift substantially decreases.

We also performed testing with HNO_3 as the etchant. Nitric acid etches the surface at a much faster rate, creating a relatively rough $GaInP_2$ surface. This allows more porphyrin to attach to the surface, regardless of etching time. In accordance with prediction, etching in HNO_3 increased the repeatability of flatband potential measurements and decreased the decay in response as the electrode was used more.

Testing of charge catalysis at the GaInP2 surface showed that the RuOEP CO and the RhOEP Cl catalyze charge transfer up to a photocurrent of 0.2 mA/cm2. However, the conduction band and Fermi level are not in water-splitting position in either of these cases. However, adding a platinum sol or ruthenium metal to the surface substantially increased flatband potential and charge catalysis. A charge catalysis study was performed on an electrode treated with ruthenium metal and RuOEP CO (as shown in Figure 4). This treatment placed bandedges in a water-splitting position up to a photocurrent of 1 mA/cm^2, or about one tenth of the intensity of the sun.

Testing was performed almost entirely in pH 4 buffer because we saw the greatest shifts in flatband potential with porphyrin treatments at that pH (see Figure 6). However, the short circuit current (SSC) is substantially improved at lower pHs. Further testing will focus on improving porphyrin response at lower pHs so as to improve the photocurrent and water-splitting efficiency.

Another area for improvement is the stability of the porphyrin on the $GaInP_2$ surface. As shown in Figure 7, CoTPP desorbs from surface after extended periods in pH 4 buffer. Further work will be performed on improving the porphyrin stability. Increasing the surface roughness or co-valently attaching the porphyrins to the $GaInP_2$ surface are options worth exploring.

An interesting result of the metal-RuOEP CO combination treatments was the decrease in hole concentration in the $GaInP_2$. This suggests that the metal-RuOEP CO treatment donates electrons into the semiconductor. The role of electron donating porphyrins in decreasing the doping density and shifting the flatband potential in a positive direction is yet to be studied.

In this research, we have substantially improved the prospects of $GaInP_2$ for photoelectrochemical hydrogen production. With further work, we will hopefully develop a system capable of splitting water powered by the sun's light. Our research has shifted flatband potentials into water-splitting condition and catalyzed charge transfer. We have the goal of further catalyzing charge transfer to meet our goal of creating a sun-powered hydrogen production system. In this work, we have come closer to our goal of replacing fossil fuels with a clean fuel, decreasing our dependence on foreign energy sources, improving livability within cities, and creating a healthier environment for the earth's ecosystems.

ACKNOWLEDGMENTS

This research was conducted at the National Renewable Energy Laboratory. I thank the U. S. Department of Energy, Office of Science for giving me the opportunity to participate in the SULI program and the chance to have an incredible learning experience. Special thanks go to my mentor John Turner for his knowledge, patience, and humor. I also thank Ashish Bansal, who started me on this project, Sarah Kurtz, who grew our $GaInP_2$ samples, and my coworkers in the Hydrogen Program.

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Tables

Treatment	V_{FB}	Standard Deviation
CoOEP	0.117	0.017
CoTPP	0.121	0.053
FeOEP Cl	0.102	0.058
FeTPP Cl	0.100	0.043
Pt sol + RuOEP CO	0.481	0.012
RhOEP Cl	0.138	0.082
$RuCl_3$ + RuOEP CO	0.488	0.207
RuOEP CO	0.266	0.182
RuTPP CO	0.161	0.091

Table 1. Results of Mott-Schottky plots in pH 4 buffer. OEP = Octaethylporphyrin, TPP = Tetraphenylporphyrin. V_{FB} = Flatband potential, which is a measure of the bandedge positions.

	Etched	Porphyrins Only	Metals Only	RuOEP CO	$RuCl_3$ + RuOEP	Pt sol + RuOEP
N_D	5.89E+16	5.17E+16	5.56E+16	5.29E+16	4.27E+16	3.36E+16
Std. Dev.	1.39E+16	1.48E+16	1.02E+16	2.08E+16	9.23E+15	1.60E+16

Table 2. Doping densities (N_D) for untreated (etched) and treated electrodes.

Figures

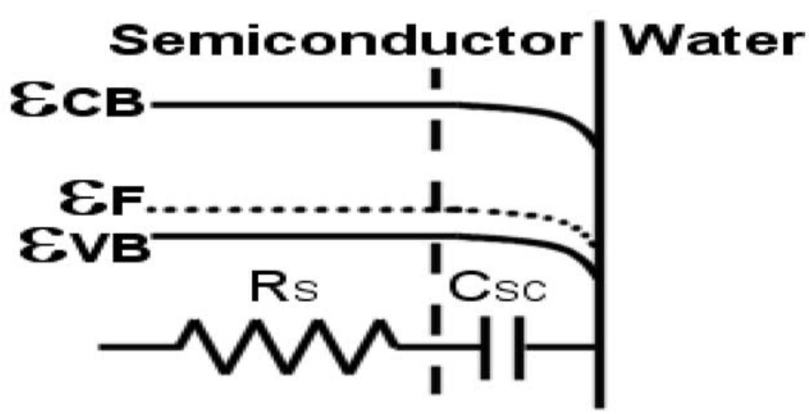

Figure 1. Modeling a p-type semiconductor as a series resistor and capacitor. R_S = System resistance. C_{SC} = Semiconductor capacitance.

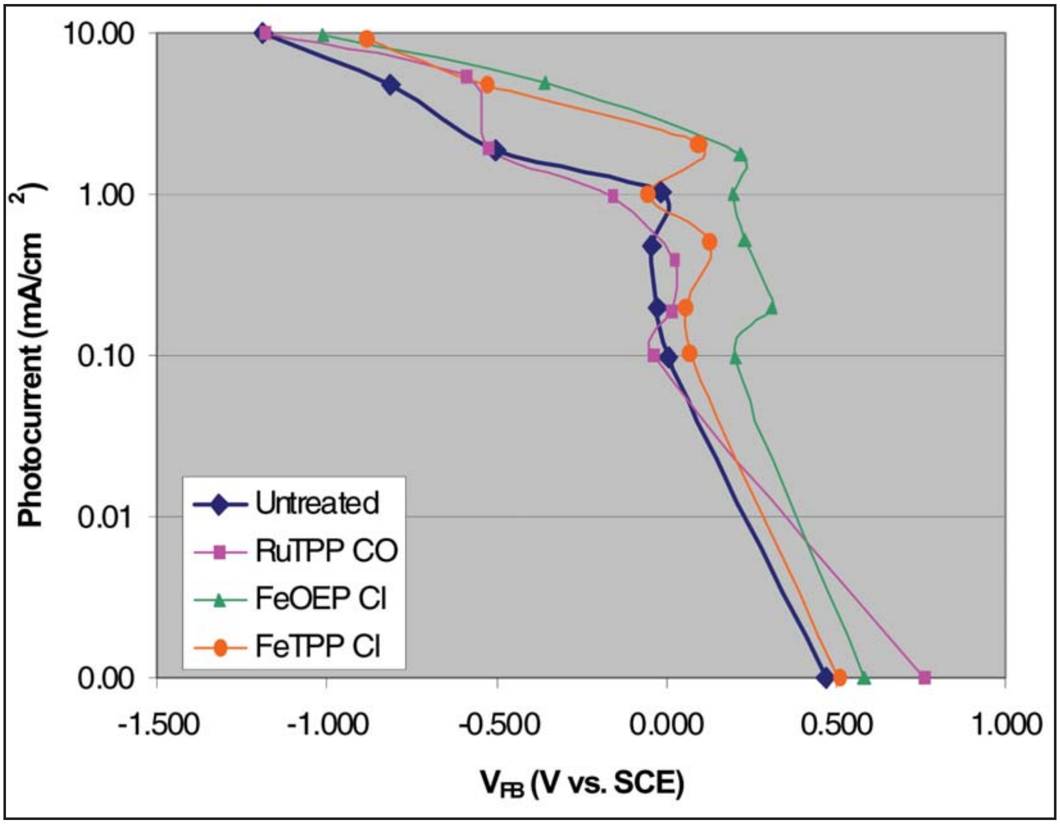

Figure 2. Charge transfer catalysis testing under increasing light intensities. Testing performed in pH 4 buffer. V_{FB} = Flatband potential, which is a measure of the bandedge positions.

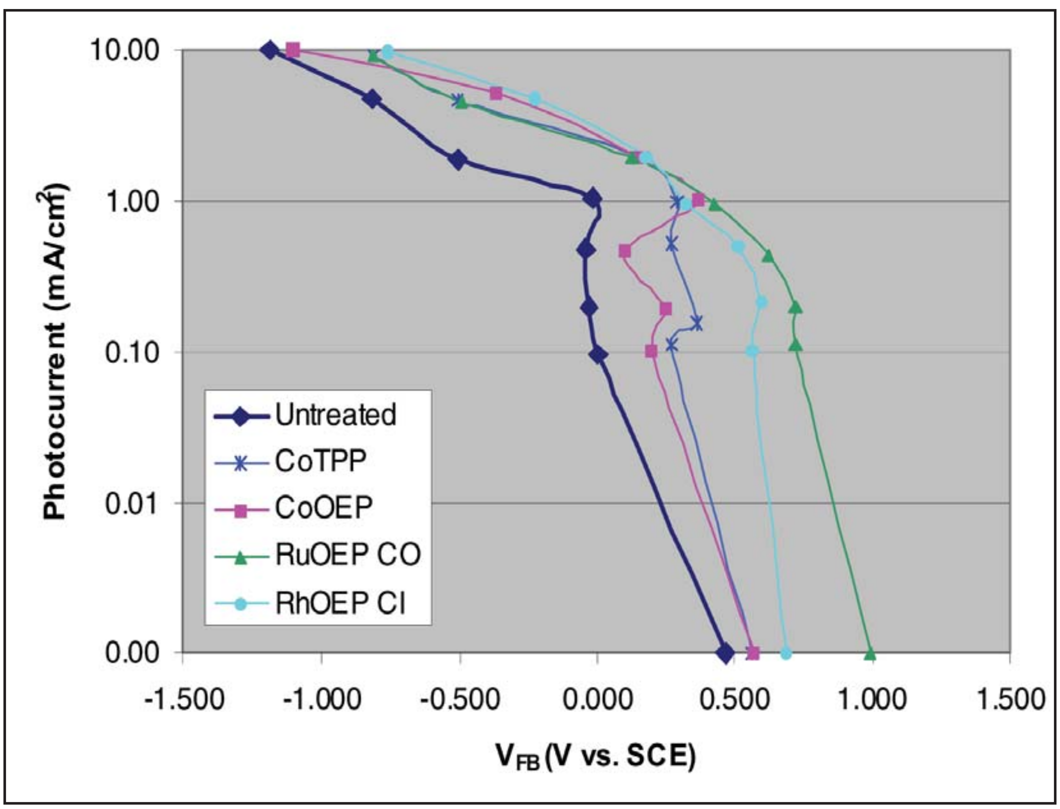

Figure 3. Charge transfer catalysis testing under increasing light intensities. Testing performed in pH 4 buffer.

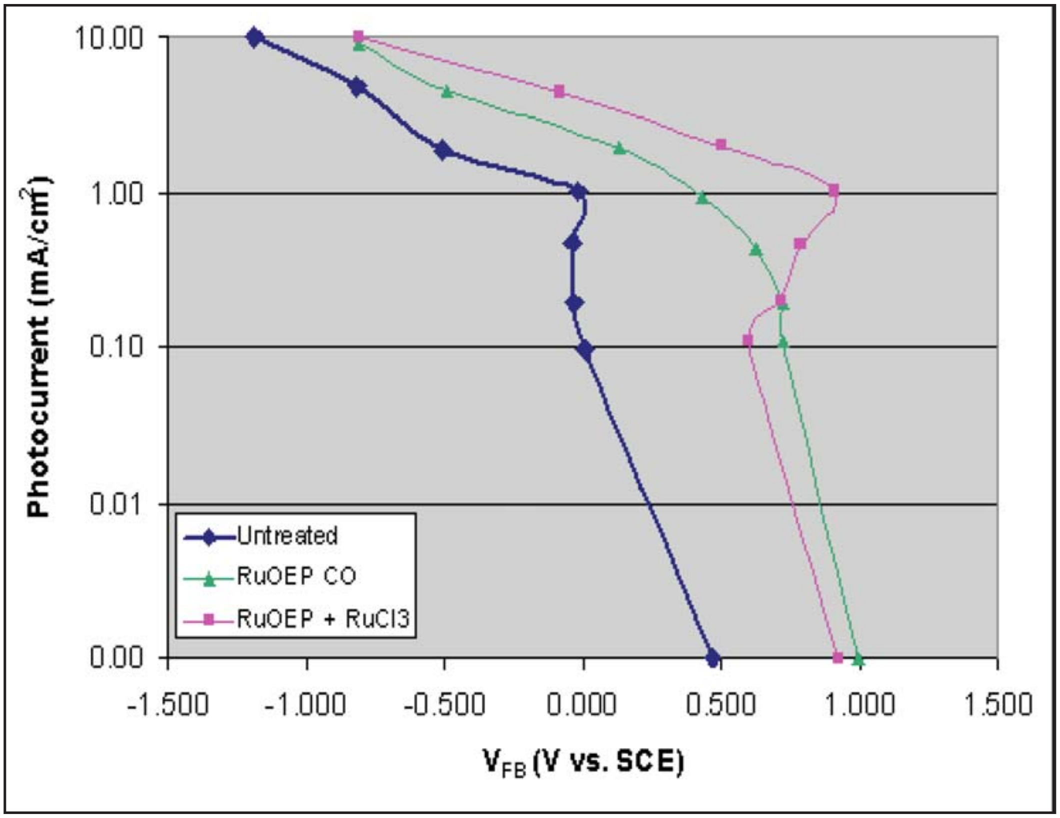

Figure 4. Charge transfer catalysis of various treatments. Testing performed in pH 4 buffer.

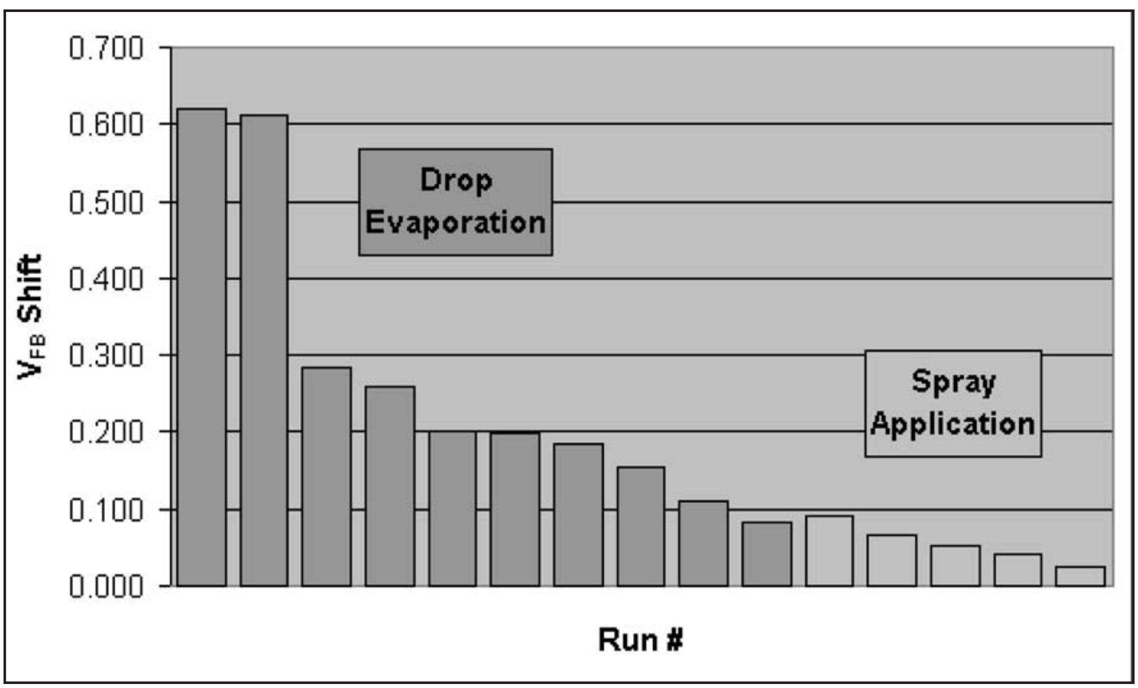

Figure 5. Comparison of drop evaporation and spray application of RuOEP CO. The magnitude of the shift in bandedge position correlates well with the thickness of the RuOEP CO application. V_{FB} Shift is the change in flatband potential between a treated and untreated electrode.

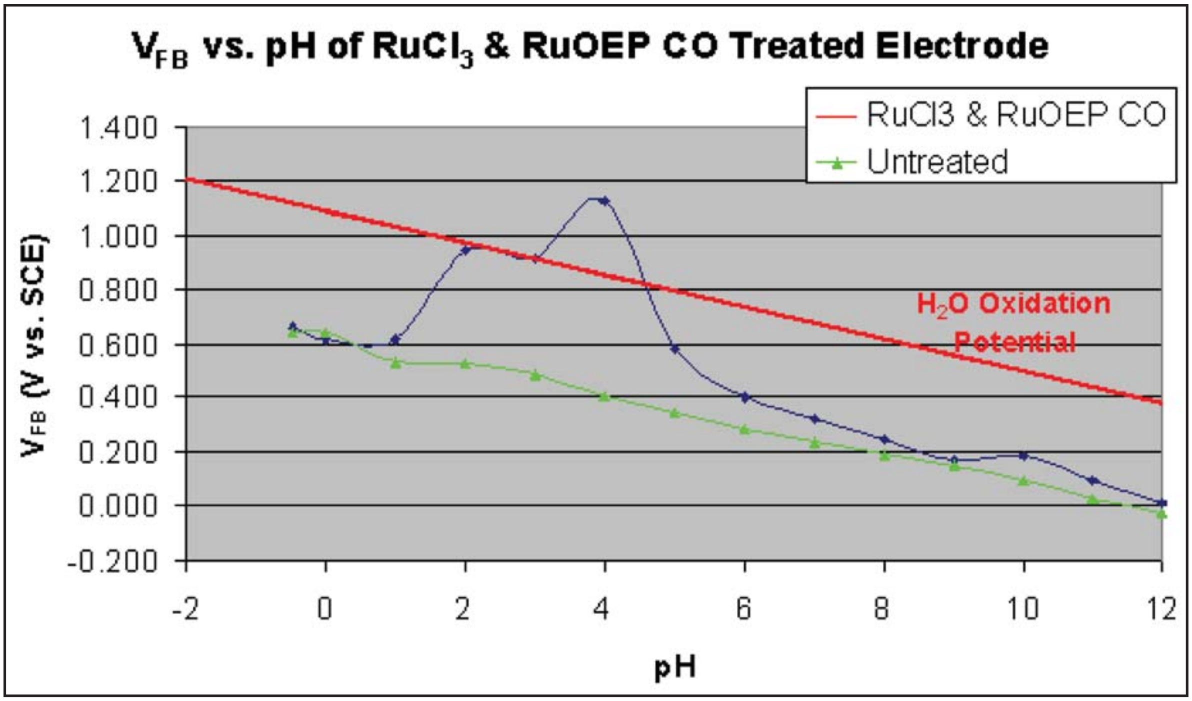

Figure 6. The effect of pH on flatband potential on an untreated and $RuCl_3$ + RuOEP CO-treated electrode.

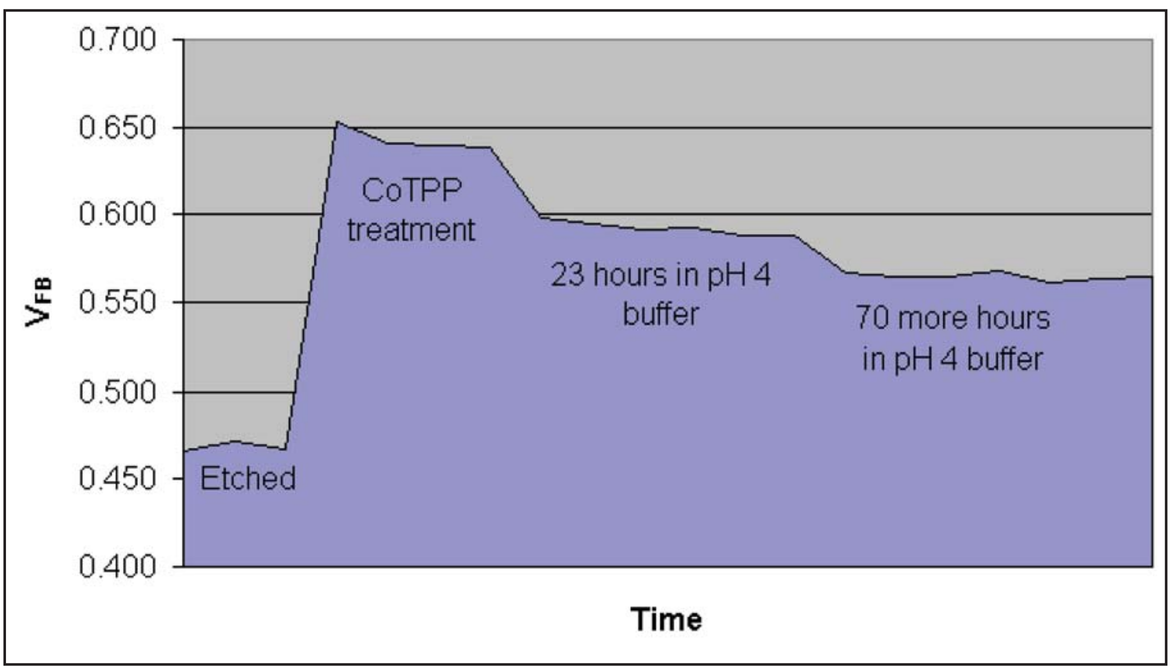

Figure 7. Possible desorption of CoTPP after immersing a CoTPP-modified electrode in pH 4 buffer for extended lengths of time.

COMPLETE SAMPLE ALTERNATIVE PAPER FORMAT

DNA Dilemma: A Perspective on Current USPTO Philosophy

Concerning Life Patents

Kale Franz

Office of Science, Science Undergraduate Laboratory Internship(SULI) Program

Colorado School of Mines

DOE Headquarters

Washington, DC 20585

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Prepared in partial fulfillment of the requirement of the Office of Science, DOE SULI under the direction of Peter Faletra in the Office of Science at DOE Headquarters.

Participant: ______________________________

Signature

Research Advisor: ______________________________

Signature

ABSTRACT

DNA Dilemma: A Perspective on Current USPTO Philosophy Concerning Life Patents. KALE FRANZ (Colorado School of Mines, Golden, CO 80401) PETER FALETRA (Office of Science, DOE Headquarters, Washington, DC 20585).

The lack of a solid set of criteria for determining patentability of subject matter—particularly subject matter dealing with life—has recently been of increasing public concern in the United States. Alarm for patent practices related to life systems ranges from patents being granted on biochemical processes and the knowledge of these processes to the patenting of entire organisms. One of the most volatile concerns is the patenting of human genes or parts of genes since this genetic material is the basic informational molecule for all life. Current patent law, legislated in 1952, has been interpreted by the U.S. Supreme Court to allow broad patents of DNA, biochemical processes, and what are generally considered "inventions" of life systems. Several issues are addressed in this paper regarding the unsound reasoning underlying both the interpretation and execution of patent law. Lapses in logic provide a gateway for businesses and individuals to take patenting to an illogical and unworkable extreme. Patent Office disorder of this magnitude is unnecessary and has great potential for harming the mission that the patent office was designed to serve. Recently disclosed patent-granting guidelines suggest the United States Patent and Trademark Office is not upholding its Constitutional responsibility of promoting the progress of science.

"Living organisms are able to reproduce themselves even if they are patented, and in view of this special quality of living organisms, the scope of a patent is difficult to define, which makes it nearly impossible to find a balance between private and public interests" [1].

INTRODUCTION

Patents on life, ranging from DNA fragments to entire organisms, have reached mainstream concern in the past few decades. It is now obvious that several fundamental problems exist with United States patent law and the system that has been established to execute that law. Through the United States Patent and Trademark Office's interpretation of Supreme Court decisions[2], patents on DNA have been deemed grantable. As this paper illustrates, it is now theoretically possible to acquire a patent on any life-related subject matter, whether the subject matter is in essence a duplication of nature or otherwise. Through the current practice of granting life patents, fundamental problems arise because of the distinct differences that exist between life and inanimate objects. At this time, the patent system needs to undergo a significant reevaluation to ensure that it is promoting the best interest of science in a sound and logical manner.

The magnitude of the current challenges facing the patent office is easily seen in the number of pending genetically related patents. Through the end of December 2000, approximately 25,000 DNA-based patents were granted [2]. Several forms of life-related subject matter have been successfully patented: Expressed Sequence Tags (EST), which serve as gene markers along a DNA strand; Single Nucleotide Polymorphisms (SNP), which are single-base variations within DNA that could potentially cause disease; and regulatory sequences—all only gene fragments—have been patented [3]. Entire genes, such as a gene called CCR5 that helps in the process of allowing HIV entrance into immune cells, have also been patented. An entire chromosome of a vertebrate is yet to be patented [4].

LEGAL JUSTIFICATION FOR DNA PATENTING

To obtain a patent on DNA of any type or scope, the DNA fragment must be isolated and purified from its (thus far) observed natural state, or the fragment must be produced in purified form in a laboratory. More specifically, the following eligibility conditions as stated in the United States

Patent and Trademark Office (USPTO) Utility Examination Guidelines, must be met:

> an excised gene is eligible for a patent as a composition of matter or as an article of manufacture because that DNA molecule does not occur in that isolated form in nature, or (2) synthetic DNA preparations are eligible for patents because their purified state is different from the naturally occurring compound. [5]

Thus, it is not acceptable to patent the exact genes as they exist in an individual [6]. However, several other logical conflicts and practical dilemmas arise from this patent philosophy.

As Condition (1) infers, one method by which DNA patents can be acquired is through patenting DNA that has been extracted from its natural environment. Since DNA is patentable, and by its very nature is part of all living organisms, any organism should be patentable by a similar mechanism to that established for the patenting of DNA. This brings about startling possibilities, the consequences of which the USPTO may have never anticipated or desired.

Entire organisms like plants, bacteria, even mice, have indeed been patented. All such patents, however, have been of an entirely different nature than DNA patents. These organisms have been fundamentally changed in some way by human ingenuity to improve upon their previous functions, abilities, and characteristics. Bacteria were genetically altered for oil-spill bioremediation purposes [7]; numerous plants have been transgenically altered for production purposes and other specific qualities [8]; mice are commonly genetically engineered as in the case of the "knockout" mice [9]: patents have been granted in all of these situations. The purification and isolation of DNA does not resemble such accomplishments. Patented DNA has simply been stripped of some of the critical parts it needs to function in a natural setting, but the base code still remains intact and unchanged by human influence.

CONDITION (1): PATENTING A TREE

Let us now consider patenting a tree by the same process that one would undertake to patent a DNA fragment under the first USPTO-defined condition. Though patenting a tree at first seems completely absurd, it is quite conceivable given current patent law and USPTO guidelines. While attempting to satisfy the requirements for patent approval legislated by Congress and interpreted by the USPTO in its execution of that legislation, the *Metasequoia glyptostroboides*—long thought extinct—will serve as our hypothetical example, though someone has yet to apply for a patent on this tree or any tree by such means. Several criteria need to be met in order to obtain a patent on *Metasequoia*. Formally, these criteria consist of non-obviousness, novelty, utility, and enablement. The first criterion however, and perhaps most logically troublesome, is that the tree must be an invention of human design. At first thought most individuals would believe it impossible for humans to invent the *Metasequoia*; it has already been created by nature. But the USPTO has a different view and exercises its duties accordingly. Patent law states that:

> Whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefor, subject to the conditions and requirements of this title. [10]

Just as DNA must be removed (purified and isolated) from the environment in which it has been observed, so too must the tree. To "invent" the *Metasequoia* we simply need to take it from central China and plant it in our own backyard. As an extra measure, we will thoroughly clean the tree so that none of the native dirt is attached to its roots, no naturally growing fungi or bacteria indigenous to the region are residing on the tree, and all other foreign material such as birds and their nests are free from the tree's limbs. *Metasequoia* has now been isolated and purified and thus is our own "invention."

The tree must be non-obvious, which is defined by the USPTO to mean that the claimed subject matter must not be obvious to a person of ordinary skill in light of what was previously known [11]. Since *Metasequoia* was thought to be extinct, its existence on Earth today was not common knowledge to those of ordinary skill in the field of botany. Given this, *Metasequoia* would also conform to the novelty requirement as well, which states that a patent cannot be granted for an entity that has already been invented by someone else [12]. While no human invented the tree as it existed in nature, and because we invented the tree as it exists outside of nature, the novelty requirement is satisfied.

Metasequoia must have utility [13]. In other words, it must be useful in at least one way. "The patentee is required to disclose only one utility, that is, teach others how to use the invention in at least one way" [14]. *Metasequoia*, as in the nature of all trees, is useful in any of a number of applications. Thus, our tree fits perfectly with the utility requirement. To meet the final requirement, our *Metasequoia* patent must show enablement.

> The specification shall contain a written description of the invention, and of the manner and process of making and using it…to enable any person skilled in the art to which it pertains…to make and use the same. [15]

To satisfy this requirement, we must simply describe in what fashion the tree was transplanted from its native land to our backyard as well as how to use it to benefit from the previously described utility.

CONDITION (2): PATENTING A PROTON

As formerly alluded to, the second condition—Condition (2)—that makes DNA eligible for patenting is satisfied after the DNA has been "synthesized in a laboratory from chemical starting materials" [16]. Hence, biologists must simply prove that they can recreate in a laboratory setting that which has already been created by nature. If patenting practices of this form are adopted by other science disciplines, perplexing and possibly undesirable consequences could result. For example, ever since Einstein proposed his famous equation $E = mc^2$, a result of the Special Theory of Relativity, it has been understood that all matter is simply a form of energy [17]. Today, scientists have the ability to manipulate energy in the vast number of particle accelerators that exist all over the world to create the various elementary particles of nature [18]—particles as common as the proton and as exotic as the Z boson. If DNA can be patented simply by synthetically creating it from more basic materials and meeting the four other conditions and requirements outlined by patent law, a proton or Z boson should theoretically be patentable because it can likewise be created. The ramifications of such patents being granted are incomprehensible.

THE DENIAL OF EXAMPLE PATENT APPLICATION IDEAS

Would the patent office ever grant a patent on *Metasequoia* or a proton in the manner that has been suggested, even though the application would comply with all of the outlined requirements in the same way DNA patent applications do? Since the patent office has yet to encounter a patent on a tree or a proton, one can only speculate upon the outcome. It inherently seems absurd to any rational person for a patent to be granted on a tree. In all probability, the patent office would reject a patent application on a tree not because of the apparent absurdity, but because of the size scale on which the patent is being proposed. The USPTO would likely not see the isolation and purification process used with *Metasequoia* as comparable to the isolation and purification that is undergone with DNA. The isolation and purification of the tree as described above is a fully tangible and visually understandable process, unlike the isolation and purification of DNA, which by its technical nature is more abstract. This dichotomy would almost certainly be enough to sway the patent office's view on the purification of the tree and thus reject the patent for not meeting the standard criteria. With the application of simple logic one can see that purification processes differing in physical size and technological scale can otherwise be quite similar. Given this, the USPTO seems to unwittingly hold a standard for patentability based on size and technological level.

Such a patent system based ultimately on size is inherently ambiguous. Size, like most any continuous system, presents natural difficulties when trying to establish arbitrary boundaries within the system. At what size does an object move from the non-patentable realm into the patentable? If DNA is patentable, then is an entire cell patentable? If an entire cell is patentable, then certainly a free-living, single-celled organism would be patentable material. If a single celled organism is patentable, then why not a multi-celled organism? Though, as mentioned earlier, patents have been granted on multi-celled organisms, all patented organisms have, to this day, been in some way genetically altered by humans and not simply the product of nature.

Similarly, it would probably be considered equally absurd to grant a patent on the proton. Protons are basic building blocks of all matter. But it follows that DNA is a basic structure of all life. For DNA to be patentable, all entities on Earth, whether devised by the creativity of humans or otherwise, must be in essence patentable. This certainly defies Congress's original intention when writing current patent law in 1952 that "anything under the sun that is *made by man*" [19] (emphasis added) be patentable subject matter.

PLAGIARIZING NATURE'S WORK

Another fundamental problem exists with the patenting of DNA. Historically, patents have been granted for inventions of an original mechanical nature or process. Plows, automobiles, and oil refinement processes have all been patented. More recently, computer chip designs and biological processes such as the polymerase chain reaction have been patented. Those patents are intrinsically different from patents on DNA fragments since they are processes or creations of humanity and not extant physical entities in nature.

Traditional patents encourage further innovation and ingenuity because it is physically possible to *invent around* the patented subject matter with a new and novel idea. However, DNA was not a human innovation, but a manifestation of nature that has undergone millions of years of evolution. By purifying and isolating DNA to patent it, humans are simply plagiarizing nature's work. Because of the innate characterisIn this regard the USPTO seems confused. The USPTO likens DNA patenting to patents on television sets and the picture tubes therein, as explained by the USPTO Director of Biotechnology Examination.

> "The USPTO views this situation as analogous to having a patent on a picture tube. The picture tube patent does not preclude someone else from obtaining a patent on a television set. However, the holder of the picture tube patent could sue the television set makers for patent infringement if they use the patented picture tube without obtaining a license." [20]

A dissection of this analogy is revealing. A Single Nucleotide Polymorphism (SNP) would be analogous to the picture tube, and a cure for a disease is analogous to the television set. Consequently an SNP patent does not preclude someone else from obtaining a patent on a cure for a disease, which is attributable to that SNP. However, the holder of the SNP patent could sue the "disease-cure" manufacturer for patent infringement if that manufacturer uses the patented SNP without obtaining a license.

The USPTO analogy is confusing, though a simple conclusion results. It is entirely possible for the television set maker to choose any of a number of picture tubes that have already been patented to use in a television set. More importantly, the television set maker can opt to design its own picture tube because it is physically possible to invent around patented picture tube innovations. Conversely, a competitor of the "inventor" of the SNP cannot pick and choose among other SNPs for a cure for the same disease since the originally patented SNP was the natural cause for that disease. Furthermore, DNA is wholly unique to this planet not because of human invention and action, but because of the forces that allowed it to evolve. Inventing around DNA therefore is entirely impossible without redesigning billions of years of evolution and "remaking" life systems altogether.

THE ROLE OF THE UNITED STATES PATENT AND TRADEMARK OFFICE

In addition to current patent guidelines seeming illogical, strong potential exists for the hindrance of the advancement of science and engineering innovation. The United States Constitution provides:

> The Congress shall have Power…To promote the Progress of Science and useful Arts, by securing for limited Times to Authors, and Inventors the exclusive Right to their respective Writings and Discoveries. [21]

The USPTO was established to execute this Constitutional mandate. Keen observers may deduce that it is the current position of the USPTO to interpret this statement with emphasis on "securing for limited Times…exclusive Right to…Discoveries." However, the purpose of the patent office is not to simply impart patents without regard for the objectives it was created to serve. The USPTO should take special care to fulfill its first and foremost duty, which is "To promote the Progress of Science and useful Arts." Strong economic and scientific advancement arguments exist on both sides of the DNA patenting issue; individuals in the scientific, academic, research, economic, and law communities are heavily divided. Through all of the controversy, it appears that the patent office is not seeking the avenue that will truly yield the most success for accomplishing its purpose, but is simply upholding previously established patent precedent. The USPTO should be more forthright about fighting to uphold its constitutional obligation of promoting the state of science. Even though "it is a long tradition in the United States that discoveries from nature which are transformed into new and useful products are eligible for patents," [22] precedent should not supersede purpose.

That the patent woes of other nations might be just as daunting as those of the United States was recently illustrated by John Keogh who successfully applied for and received a patent in Australia for…the wheel. He does not expect to make money from the patent but did receive worldwide attention and the 2001 Ig Nobel Award in Technology [23].

ACKNOWLEDGEMENTS

This research was conducted at the U. S. Department of Energy Headquarters. I would like to take this opportunity to express my sincere gratitude to my mentor Peter Faletra. He has been an inspiration and has given me a great deal of direction and desire to continue my ongoing pursuit of science. I would also like to thank Cindy Musick and Sue Ellen Walbridge for all of the support and guidance they have given me throughout my internship. Additionally, I would like to thank the Department of Energy, the Office of Science, and the SULI Program for allowing me the opportunity to participate in such an exceptional and fulfilling internship program.

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[2] *Diamond v. Chakrabarty*, 447 U.S. 303 (1980)

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[10] 35 U.S.C. § 101

[11] 35 U.S.C. § 103

[12] 35 U.S.C. § 102

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[14] Utility Examination Guidelines, 66 Fed. Reg. 1,094 (2001)

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[20] Doll, J. J. "The patenting of DNA." Science, 280, (1998, May 1) 689-690.

[21] United States Constitution, Article 1, Section 8, Clause 8

[22] Utility Examination Guidelines, 66 Fed. Reg. 1,093 (2001)

[23] "Scientific Prizes." Science, 294 (2001, Oct. 12) 285.

Note: These references are not necessarily formatted in IEEE style because the IEEE citation format is not designed for legal citations and is thus silent on the format for several legal sources.

PART 5: THE ORAL PRESENTATION

The oral presentation should have an approximate duration of 15 minutes. The objective of an oral presentation is to communicate information to other scientists.

Elements of an effective oral presentation include:

The Speaker

- Keep in mind that your objective is **communication of information.** Mumbling, monotone speech, and use of obscure terminology are not effective methods of communication.
- Engage the audience. An oral presentation can be informative, exciting, and even humorous.
- You are a speaker, not a reader. Take advantage of the verbal medium.

Presentation Materials

- Use visual aids whenever possible. A picture is worth a thousand words and a graph is worth a thousand numbers.
- A picture is worth a thousand words only if the purpose of the picture is clear. Clearly introduce any graph, table, or picture. It is often difficult to read graphs on overhead projections, so verbally repeating some things (such as the legend and axes of a graph or the magnification of a micrograph) can assist the audience.
- Demonstrations, models, short videos can all be effective means of communication.
- Limit the number of slides or frames in a PowerPoint presentation. Too many slides can be distracting from the main point of your research.

The Structure of the Presentation

- At the start of the presentation the speaker should introduce herself/himself and identify both the sponsoring organization and other contributors to the research.
- As in most technical presentations, it is best to give some background information on the subject. This allows both the speaker and the audience to place the topic in perspective before the technical information is presented.
- Clearly communicate what you intended to accomplish in your work and how your research relates to the larger body of research in the field.
- Do not spend time describing the details of well-known techniques.
- If you made little progress during your research, describe what problems held up your progress and how, if given more time, you might have overcome those problems.
- Describing plans for future experiments is a common way to end a presentation.

PART 6: THE POSTER PRESENTATION

Purpose

The primary purpose of the poster presentation is to provide an opportunity for communicating the results of research and to promote discussion among science colleagues. Because poster presentations are usually done in groups, with observers milling around a large room of posters, the presentations are relaxed and more conducive to the exchange of ideas and techniques between presenters and observers.

The poster presentation (main body - Introduction, Methods and Materials, Results and Discussion) should be no longer than 15 slides. The Title Page, Table of Contents, Abstract, Literature Cited, Acknowledgements and any tables and figures are part of the fifteen-slide limit. An electronic copy in MS PowerPoint must be uploaded via your eduLink account. You should also submit a hard copy to your mentor and your laboratory education program manager before the end of your internship.

The Poster

A good poster is uncluttered and clear in design. It has legible text and logical organization. The main tenet of a good poster design is simplification. Use a crisp, clean design and a strong title. Do not tell the entire research history; present only enough data to support your conclusions and show the originality of the work. The text material should be reduced to convey your points quickly and clearly. Many successful posters display a succinct statement of major conclusions at the beginning, followed by supporting text in later segments, and a brief summary at the end.

- Allow ample time, at least two weeks, to prepare your poster.
- All lettering should be legible from about 3 feet (1.5m) away.
- Text material is ideally

  24 point (1/4”, .625cm)

  and no less than

  18 point

Poster elements should be mounted with an adhesive on white or colored poster board. A professional appearance is achieved by mounting illustrations and captions on colored poster-board with a ¼” to a ½” border as a frame. Double mounting with different colored poster board is a clever way to color coordinate different sections of the poster.

For ease of transport, make the poster elements small enough to package and carry (approximately 17" x 22", 42.5cm x 55cm). Be sure to pack a measuring tape and a sketch of the poster layout so you will be prepared to set up the poster quickly.

Posters should feature a title, your name, the name of the institution where the research was performed, the sponsor (Department of Energy), and should credit persons who have helped you with your research.

Preparation

- The top of the poster should consist of an easy-to-read and easy to understand Title that includes author(s) name(s). The title lettering should be about 2" to 3" (5cm to 7.5cm) with subheadings 1/2" to 1" high (1.25cm to 2.5cm).

- All lettering should be legible from about 3 feet (~1.0 m) away. The minimum type size for text should be no less than 18 points, but 24 points (I /4", .625cm) is preferable.

- The component parts should be organized in a way that leads the viewer through the display. Colored matting can be very effective here.

- Leave some open space in the design.

- Use elements of different size and proportions. Convert tabular material to graphic display, if possible.

- A large and/or bright center of interest can draw the eye to the most important aspect of the poster. Use color to add emphasis and clarity.

- Make illustrations simple and bold. Enlarge photos to show pertinent details clearly.

- All illustrations, graphs and pictures should have their own attached explanations.

- Displayed materials should be self-explanatory, freeing you for discussion.

- Handouts of your abstract should be available for interested viewers.

- Demonstrations of experiments or three-dimensional displays are not typical of a poster session.

*These Instructions were taken, in part, from the AAAS-American Junior Academy of Science Poster Session guidelines for the year 2000.

Title Slide

Characterization of the Microbial Community in a Methane-Driven Denitrifying Bioreactor

BERKELEY LAB

Ana C Fernandez,
William Stringfellow, Gary Andersen

United States Department of Energy

UNIVERSITY OF FLORIDA

Gainesville, FL 32611

Abstract Slide

BERKELEY LAB

Abstract

LAWRENCE BERKELEY NATIONAL LABORATORY

Denitrification is an important step of the wastewater bioremediation process. It involves the removal of nitrogenous compounds from wastewater, known to cause adverse effects to human health and the environment. Because denitrification is the last step in the wastewater bioremediation process, a supplemental source of organic carbon must be added at a significant cost to wastewater treatment plants. Methane may be an inexpensive alternative source of organic carbon for denitrification. Previous studies suggest that coupled anaerobic methane oxidation and denitrification may be an effective, low cost alternative to facilitate the denitrification process in wastewater treatment plants. Understanding the microbial community present in a coupled anaerobic methane oxidation denitrifying system may allow for optimization of denitrification in wastewater treatment facilities. In this study, a low oxygen, methane-oxidizing denitrifying bioreactor (MOR) is used to emulate a coupled anaerobic methane oxidation denitrifying system. Methanotrophic and denitrifying bacteria are expected to be the major constituents of the MOR. 16S rDNA sequencing via microarray hybridization is used to identify the microbial community of the MOR. Results show that five bacterial subgroups represent the major constituents of the microbial community of the MOR, including members of the *Bacillus* subdivision known to reduce nitrate to nitrite. Denitrifying bacteria are indeed the major constituents of the microbial community of the MOR. However, 16S rDNA microarray technology is unable to detect the presence of known methanotrophic bacteria in the MOR. The 16S rDNA microarray must be optimized to detect methanotrophic bacteria. Additionally, the microarray technology is used to identify the microbial communities of an ammonia-oxidizing bioreactor (AOR) and a hydrogen membrane bioreactor (HMBR). As expected, distinct microbial communities are found in each of the three bioreactors using the 16S rDNA microarray. Results show that the 16S rDNA microarray is effective for the identification of distinct microbial communities in different bioreactors.

Introduction and Hypothesis Slides

Objectives

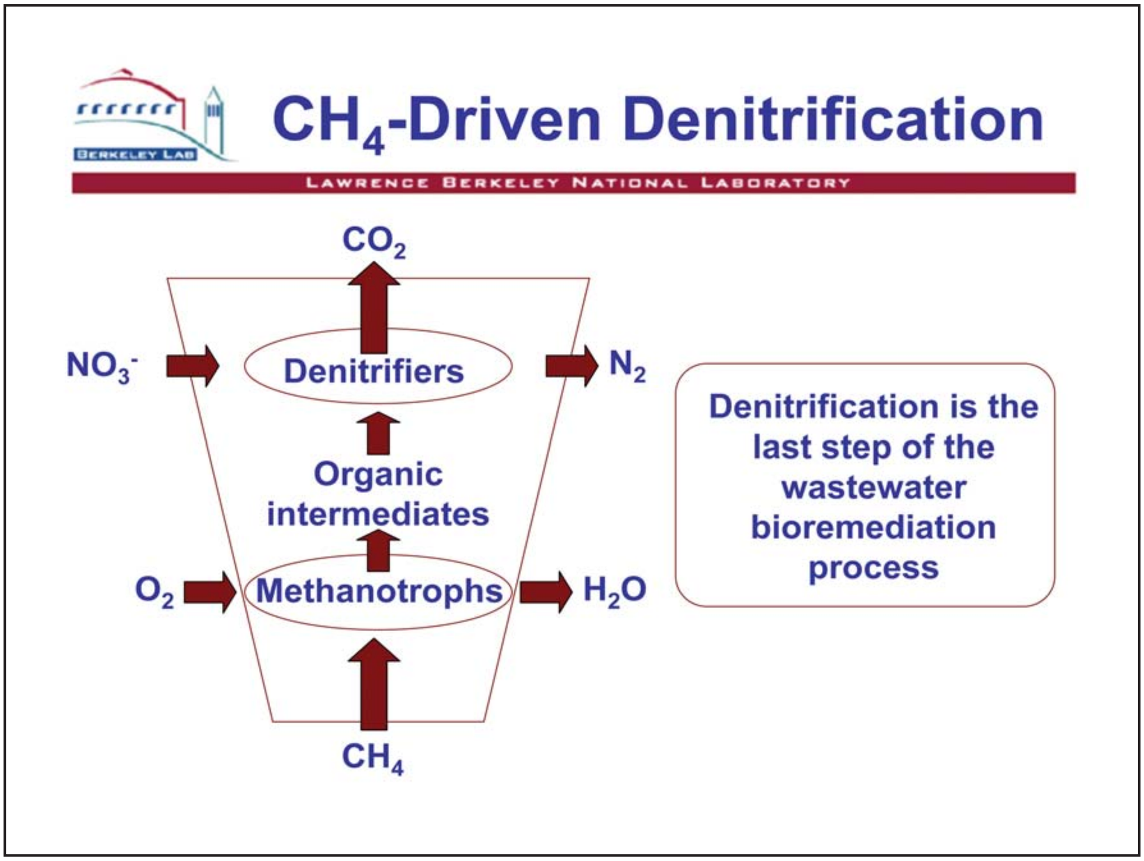
LAWRENCE BERKELEY NATIONAL LABORATORY

1. To characterize the microbial community in a methane-driven denitrifying bioreactor (MOR) using 16S rDNA sequencing via microarray hybridization
2. To determine the effectiveness of the 16S rDNA microarray for the identification of the microbial communities of three distinct bioreactors

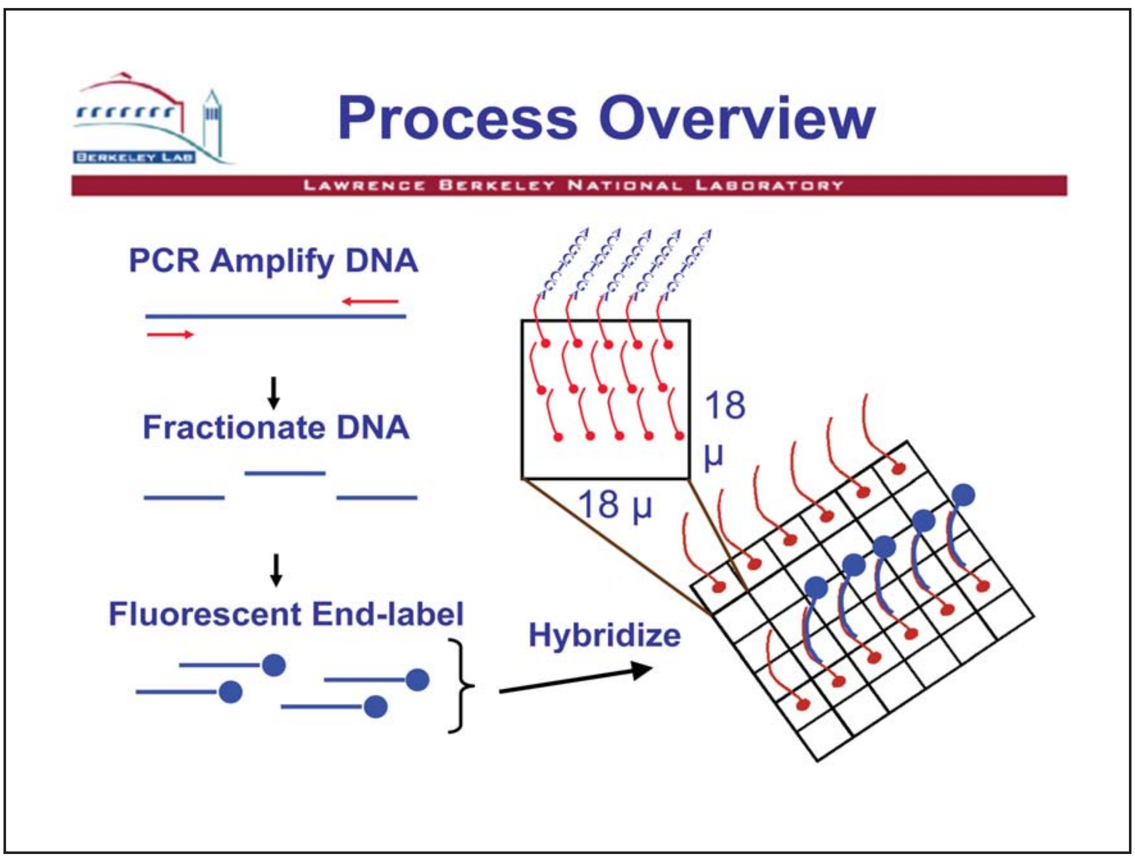
Hypotheses

LAWRENCE BERKELEY NATIONAL LABORATORY

1. The microbial community in the methane-driven denitrifying bioreactor (MOR) is primarily composed of methanotrophic and denitrifying bacteria
2. Each of the different bioreactors has a distinct microbial community that is related to its function



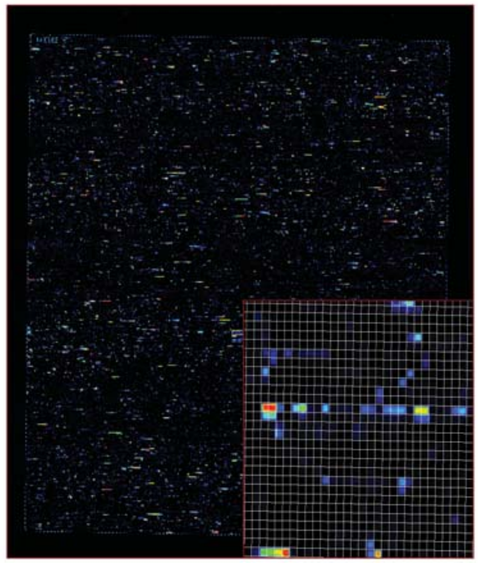
Methods and Materials Slides



Microarray Analysis

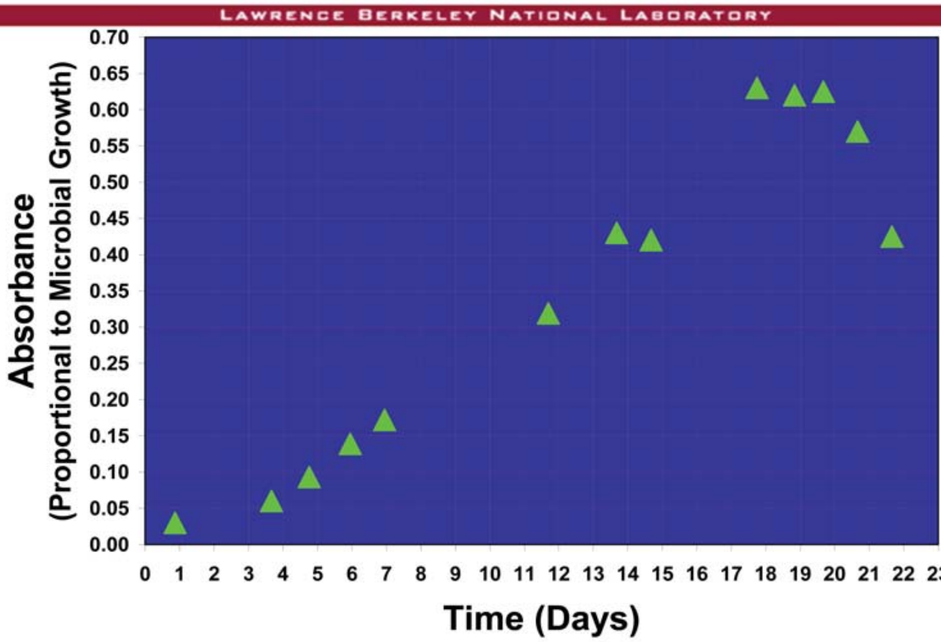
LAWRENCE BERKELEY NATIONAL LABORATORY

- 500,000 probes designed to match 9,900 target 16S rDNA sequences
- Fluorescence upon probe-target match indicating positive ID of a species



Microbial Growth in MOR

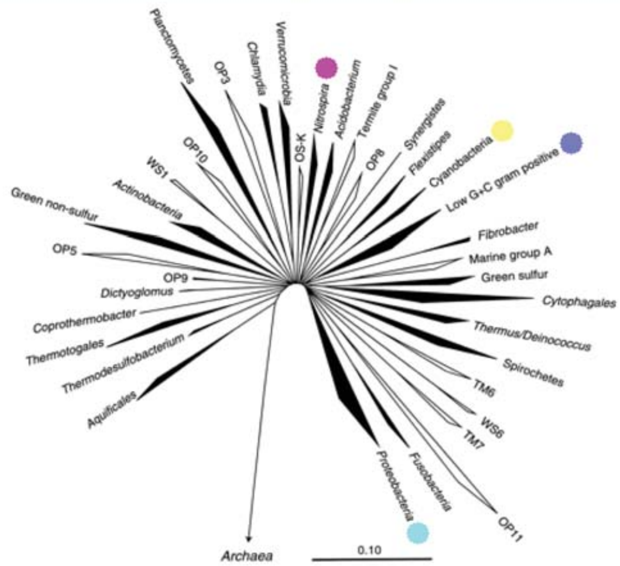
LAWRENCE BERKELEY NATIONAL LABORATORY



Results Slides

Bacterial Kingdom Diversity

LAWRENCE BERKELEY NATIONAL LABORATORY



Major Bioreactor Constituents

LAWRENCE BERKELEY NATIONAL LABORATORY

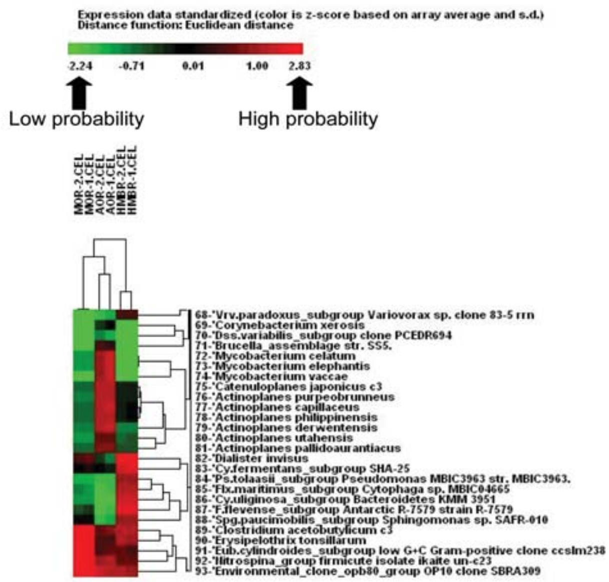
		Bioreactors		
Bacterial Phylogeny	**Relation to Bioreactor Function**	**Methane-Oxidizing**	**Ammonia-Oxidizing**	**Hydrogen Membrane**
B.ALCALOPHILUS_SUBGROUP (2.30.7.9.3) Sporolactobacilus_Group Bacillus-Lactobacillus-Streptococcus_Subdivision Gram positive Bacteria	*Bacillus* -reduces nitrate to nitrite under anaerobic conditions	X		
STC.PNEUMONIAE_SUBGROUP (2.30.7.21.9) Streptococci Bacillus-Lactobacillus-Streptococcus_Subdivision Gram positive Bacteria	*Bacillus* -reduces nitrate to nitrite under anaerobic conditions, *Streptococci* -fermentative aerotolerant anaerobe	X		
LPTX.DISCOPHORA_SUBGROUP (2.28.2.9.5.4) Leptothrix_Subgroup Acidivorax_Group Beta_Subdivision Proteobacteria	*Leptothrix* -sheathed bacteria common in freshwater habitats that are rich in organic matter	X	X	X
ENVIRONMENTAL_CLONE_III1-8_GROUP (2.13.6) Nitrospina_Subdivision	*Nitrospina* -oxidize nitrite to nitrate, chemolithotrophic bacteria involved in nitrogen cycling in marine waters	X	*	X
CHLOROPLASTS_AND_CYANELLES (2.21.2) Chloroplasts and cyanelles Cyanobacteria and chloroplasts	*Cyanobacteria* -principal nitrogen fixers, oxygenic phototrophs	X		X

X indicates presence of bacteria in bioreactor
*** indicates one of the replicates is slightly below the positive fraction cutoff**

Discussion and Conclusions Slides

Bioreactor Bacterial Diversity

LAWRENCE BERKELEY NATIONAL LABORATORY



Conclusions

LAWRENCE BERKELEY NATIONAL LABORATORY

- Denitrifying bacteria are dominant organisms in the microbial community of the MOR
- 16S rDNA microarray sequencing is effective in the identification of organisms unique to each bioreactor
- Leptothrix and nitrifying bacteria are very likely present in all three bioreactors
- Nitrogen-fixing bacteria are present in the MOR and the AOR
- Known methane oxidizers were not observed using the microarray technology

Future Work

LAWRENCE BERKELEY NATIONAL LABORATORY

- Monitor nitrate consumption/nitrogen gas production in MOR
- Track methane consumption/organic carbon production in MOR
- Optimize microarray technology for the detection of methane oxidizers
- Study the effects of time on microbial community development
- Determine limiting substrates for microbial community development

Acknowledgements/References Slides

Acknowledgements

LAWRENCE BERKELEY NATIONAL LABORATORY

- United States Department of Energy
- Lawrence Berkeley National Laboratory
- Center for Environmental Biotechnology
- Andersen Group
- Stringfellow Group

PART 7: THE EDUCATION MODULE

For the Pre-Service Teacher Program
Education Module Template

TITLE:

Name of lesson plan.

AUTHOR:

Name of Author.

GRADE LEVEL/SUBJECT:

Mention all the subjects that will be included in your lesson plan as well as grade level(s).

CURRICULUM STANDARD:

List the AAAS, National Science Education Standards – National Research Council, NCTM, state or national standards that this lesson plan meets.

OVERVIEW:

A brief summary of your activity.

LEARNING OBJECTIVES:

What will students learn or accomplish from completing this lesson?

TIME ALLOTTED:

How much time will you need to teach your entire lesson?

VOCABULARY:

List the words that students need to be familiar with in order to understand the material that will be covered in this lesson plan.

RESOURCES/MATERIALS:

List supplies or resources needed (encyclopedias, Internet resources, email, newspapers, handouts). If you used handouts, list the handouts that students will use during the lesson.

Note: For each of the following sections, list specific steps you would take to carry out the lesson.

PREREQUISITE KNOWLEDGE:

What does a student need to know before beginning this activity?

MAIN ACTIVITIES:

List the steps needed to introduce the activity to students. Do you make a presentation to the entire class or to small groups of students? List steps for body of lesson.

EVALUATION:

How will you assess student's acquisition of knowledge or demonstrate student's progress toward the standards that your lesson addresses?

COMPLETE SAMPLE EDUCATIONAL MODULE

TITLE

A Scientific Investigation on Alcohol Fermentation and Biomass Conversion

AUTHOR

Nicole Buyck

GRADE LEVEL/SUBJECT

AP (Advanced Placement) Biology
Grades 11 and 12
Three *90 minute periods*

CURRICULUM STANDARD: AAAS BENCHMARKS. PROJECT 2061.

SECTION 1, THE NATURE OF SCIENCE.

By the end of the 12th grade, students should know:

- **1B Scientific Inquiry:** Hypotheses are widely used in science for choosing what data to pay attention to and what additional data to seek, and for guiding the interpretation of the data (both new and previously available).

SECTION 5, THE LIVING ENVIRONMENT.

By the end of 12th grade, students should know:

- **5C Cells:** Complex interactions among the different kinds of molecules in the cell cause distinct cycles of activities, such as growth and division. Cell behavior can also be affected by molecules from other parts of the organism or even other organisms.

SECTION 9, THE MATHEMATICAL WORLD
.
By the end of 12th grade, students should know:

- **9B Symbolic Relationships:** In some cases, the more of something there is, the more rapidly it may change (as the number of births is proportional to the size of the population). In other cases, the rate of change of something depends on how much there is of something else (as the rate of change of speed is proportional to the amount of force acting).
- **9B Symbolic Relationships:** Tables, graphs, and symbols are alternative ways of representing data and relationships that can be translated from one to another.

SECTION 11, COMMON THEMES.

By the end of 12^{th} grade, students should know:

- **Constancy and Change:** Graphs and equations are useful (and often equivalent) ways for depicting and analyzing patterns of change.

SECTION 12, HABITS OF MIND.

By the end of 12^{th} grade, students should know:

- **12B Computation and Estimation:** Use computer spread-sheet, graphing, and database programs to assist in quantitative analysis.
- **12B Computation and Estimation:** Compare data for two groups by representing their averages and spreads graphically.
- **12C Manipulation and Observation:** Learn quickly the proper use of new instruments by following instructions in manuals or by taking instructions from an experienced user.
- **12C Manipulation and Observation:** Use computer technology for producing tables and graphs and for making spreadsheet calculations.
- **12D Communication Skills:** Choose appropriate summary statistics to describe group differences, always indicating the spread of data as well as the data's central tendencies.
- **12D Communication Skills:** Participate in group discussions on scientific topics by restating or summarizing accurately what others have said, asking for clarification or elaboration, and expressing alternative positions.
- **12D Communication Skills:** Use tables, charts, and graphs in making arguments and claims in oral and written presentations.

OVERVIEW

This three-day lesson will allow students to enhance their laboratory technique, as well as familiarize them with using software (such as Microsoft Excel) to manipulate data, create graphs, and interpret results. Students will perform two investigations concerning biomass conversion to ethanol. Students are expected to use the scientific method in order to create their own scientific investigation.

LEARNING OBJECTIVES

- Students will be introduced to the industrial uses of metabolic pathways.
- Students will gain a better understanding of the fermentation process and its industrial use for biomass conversion.
- Students will be able to use the scientific method to create their own scientific investigations.
- Students will be able to use computer software (Microsoft Excel) to create spreadsheets for data, as well as graphs (including appropriate equations and statistical calculations).
- Students will be able to correctly interpret data, and to use charts and graphs to communicate their findings to others.
- Students will be able to compare data sets and draw educated conclusions about causes of variation.

VOCABULARY

Amylase
Assay
Buffer
Cuvette
Ethanol
Fructose
Metabolic Pathway
Non-Renewable Energy
Spectrometer
Starch
Yeast Media
Anaerobic
Biomass
Centrifuge
Enzyme
Fermentation
Glucose
Microsoft Excel
Renewable Energy
Spreadsheet
Sucrose

MATERIALS

FERMENTATION MATERIALS

- **Safety glasses**
- Cornstarch (or soluble potato starch)
- Table sugar (sucrose)
- Fructose
- Glucose (dextrose)
- Peptone
- Yeast extract
- Baker's yeast
- Other yeast varieties
- Amylase enzymes:
  - Maxamly from Gist-brocades
  - Amyloglucosidase from Sigma Diagnostics (A 7255)
  - Alpha Amylase from Sigma Diagnostics (A 6211)
- Deionized water
- Stirring rod
- Hot plate
- Thermometer
- Autoclave or pressure cooker
- 125 ml Erlenmeyer flask
- Rubber stopper with hole and tube
- Pipette (including ones that can measure in microliters – may be substituted for a syringe that can accurately measure in microliters)
- Graduated cylinder
- Balance that can accurately weigh to the hundredth of a gram
- Centrifuge
- Parafilm
- Stir plate and stir bar

- Grease pen

ETHANOL ASSAY MATERIALS

- **Safety glasses**
- **Gloves**
- Ethanol assay kit from Sigma Diagnostics (catalog number 332-A)
  - NAD-ADH Single Assay Vial (individual catalog number 330-1)
  - Ethanol Standard Set (individual catalog number 332-11)
  - Glycine Buffer Reagent (individual catalog number 332-9)
- Spectrometer that can read at 340 nm
- Cuvettes or tubes appropriate for the spectrometer
- Kimwipes
- Saline
- Syringe and needle

CARBON DIOXIDE ANALYSIS MATERIALS

- **Safety glasses**
- **Gloves**
- Rubber tubing
- Ring stand and clamps
- 50 ml burette or pipette with stopper
- Bromthymol Blue *(alternative spelling Bromothymol)*
- Tube (minimum one liter)

DATA ANALYSIS MATERIALS

- Computer with Microsoft Excel
- Printer
- Disks for data storage

PREREQUISITE KNOWLEDGE (ONE DAY)

PREVIOUS KNOWLEDGE AND LESSONS

- At this point in the semester, students should already understand the scientific method. In addition, students should know general laboratory procedures, such as taking measurements, data collecting, and record keeping. Although this laboratory experience will strengthen their understanding of the scientific method, it should not be a new concept, and this should not be the first time students are asked to use the scientific method for their laboratory investigations.
- Students should have an introduction to Microsoft Excel before performing the Data Analysis section of this activity. Students should be introduced to the concept of using a spreadsheet and how to convert Excel spread-sheets into graphs.
- This activity is meant to be part of a unit on metabolic pathways. It is best done in conjunction with lessons surrounding glycolysis, cellular respiration, Krebs (TCA) cycle, fermenta-

tion (anaerobic respiration), and photosynthesis. Students should understand the big concepts behind these and other metabolic pathways, especially those surrounding fermentation. This activity should enhance students' understanding of the industrial uses of metabolic pathways, with a focus on biomass conversion (fermentation of corn to ethanol).

DAY ONE - INTRODUCTION AND LABORATORY PREPARATION

PART ONE : INTRODUCTION

- Review of metabolic pathways with an emphasis on fermentation and anaerobic respiration.
- Class discussion: How do we use the metabolic pathways of other organisms (especially microorganisms like bacteria and yeast)? Answers may be written on an overhead, the board, or in student notebooks. The teacher should facilitate this discussion by guiding students to appropriate answers.
- Discussion should be wrapped-up with an emphasis on biomass conversion. This is a good lead-in to the laboratory investigation.
- At times, the teacher should suggest a few uses that the students may not think of or elaborate on student answers (see the following text).

Food industry
- beer, wine, root beer
- vinegar
- yogurt, cottage cheese, cheese, custard, butter
- sauerkraut
- breads
- sausage, pepperoni, salami
- uses yeast, bacteria
- uses enzymes:
    - chymosin for cheese production
    - amylase to break down starch
    - glucose isomerase to get sweeter products
    - pectinase to clarify fruit juices
    - glucose oxidase to dry egg whites

Drug industry
- organism produces drug as a by-product of metabolic functions
- antibiotics (Penecillin)
- vitamins (A, B2, B12, Biotin, C)

Chemical industry
- acids (lactic acid, acetic acid)
- alcohols (ethanol)
- others (cellobiose, glucose, xylose, arabinose, xylitol, glycerol)

Symbiotic relationships
- digestion
- lactose-intolerance

Biomass conversion
- plant matter
- corn to ethanol

PART TWO – LABORATORY PREPARATION

- Overview of three-day laboratory investigation. Remind students that on the third day they will be meeting in the computer lab for data analysis.
- Hand out instructions for the laboratory.
- Review vocabulary as needed.
- Students work in pairs and follow instructions for the first fermentation set-up.
- Students work in pairs to design their own fermentation investigation using the scientific method. Before the fermentation is set-up, students report hypothesis and variables to instructor for verification.
- Students keep notes on experiment design in laboratory notebooks and answer questions in the laboratory handout.

MAIN ACTIVITIES

<u>DAY TWO – IDENTIFICATION AND QUANTIFICATION OF FERMENTATION PRODUCTS INTRODUCTION</u>

- Remind students that on the following day they will be meeting in the computer lab for data analysis.
- Warm-up activity: Ask students to write the chemical equation for the fermentation reaction they set-up the previous day. As a class, go over the reaction and allow students to brainstorm ways they could identify the products. Ask how the products might be quantified.
- Brief review of the carbon dioxide test and the ethanol endpoint assay. If students have not used a spectrometer or a centrifuge before, a brief review on how to use the device may be needed.
- Review vocabulary as needed.

PART ONE – CARBON DIOXIDE ANALYSIS

- Students confirm the presence of carbon dioxide as a product in both fermentation reactions (using Bromthymol Blue).
- Students quantify the carbon dioxide production and make quick comparisons and generalizations between both fermentation reactions (using water displacement).
- Students record data in lab notebooks and answer the questions in the lab handout.

PART TWO : ETHANOL ANALYSIS

- Students run the ethanol standards and record data in lab notebooks.
- Students confirm the presence of ethanol and quantify it for each fermentation reaction (using ethanol assay – blood alcohol kit from Sigma Diagnosis).
- Students record data in lab notebooks and answer the questions in the lab handout.

DAY THREE – DATA ANALYSIS AND MANIPULATION INTRODUCTION

- Quick review of the day's activities.
- Review vocabulary and Microsoft Excel commands as needed.

PART ONE – DATA ANALYSIS AND MANIPULATION

- Students use Microsoft Excel to create a spreadsheet for the data.
- Students use Microsoft Excel to create graphs for data interpretation.
- Students extrapolate data according to calculations.
- Students write in lab notebook: conclusions (what did they discover about their original hypothesis); ideas for further investigations – what other hypotheses can be made and how can they be tested?

PART TWO – CLASS DISCUSSION (WRAP-UP)

- Students share their own investigations as well as their findings from the data analysis. The class discusses general conclusions about the fermentation process and what variables affect the quantity of ethanol and carbon dioxide production.
- Students share ideas for further investigations.

EXTENSIONS (Optional)

- Students may research the industrial uses of metabolic pathways of other organisms (see list from preparatory activities).
- Websites with experiments on food production using fermentation:

http://www.uwrf.edu/biotech/workshop/activity/act1/act1.htm

http://www.lcsc.edu/ns172/Outlines/fermenthome.html

http://www.wsu.edu:8080/~hurlbert/pages/101lab16.html

http://www.inform.umd.edu:8080/EdRes/Topic/AgrEnv/ndd/4h/

- Allow students to perform further investigations based on answers to laboratory questions.
- Talk about the uses of the ethanol assay for testing blood-alcohol levels.

EVALUATION*

Excel spreadsheets and Excel graphs can be evaluated using a rubric that is developed with the class that lists the elements that they feel were important and should be included in a quality product.

Students can make power point presentations or poster type presentations that can be assessed by the other students in the class and the teacher both, using a pre-constructed rubric. These presentations should include all data collected in the experimental process, observations and changes made during the experiment, and conclusions developed.

Lab notebooks can be exchanged with other pairs of students to make comments on their data and experimental procedure. A rubric could be developed with the entire class on what should be included in each notebook, and the pairs of students could then evaluate one other lab notebook. The teacher can then also assess the lab notebooks for accuracy and completeness.

A brief written assessment piece could be given where students explain in an essay format what they learned from the lab. This should include an explanation of how to use a spectrometer, centrifuge and Excel to document lab results. The students could be asked to explain how this experiment might be used in the real world, and what they discovered about their original hypotheses and what other hypotheses could be made as a result of their data collection and how these might be tested.

* This evaluation was not written by the author of this lesson plan. It has been added as an example only to give direction in what a possible assessment might look like.

PART 8: THE PERSONAL IDEA JOURNAL

During your time as a Pre-Service Teacher intern, you will have many opportunities to document the processes of science which can then be integrated into your future classroom. The personal idea journal is designed to help you document these opportunities in a way usable to you. The following is a listing of possible organizational strategies that you may follow, but you may choose any format that makes sense to you and that you would use as you begin your first teaching position.

Possible Organizational Strategies

1. *Timeline*
   This organizational method documents integration ideas as you encounter them in your internship. Some people remember where things are if they have a chronological ordering to look back on and refer to.

2. *Subject Listing*
   Since you may be teaching a variety of subjects related to math or science, you may find it useful to divide your journal into subject specific areas such as Classroom Management, Language Arts, Computer/Technology, Chemistry, Physics, Life Science, Math, General Science, etc. List the grade level most appropriate for each idea.

3. *Grade Level*
   You may not know the grade level of your first teaching assignment therefore a listing of grade level ideas may be the most beneficial.   Sorting by early elementary, intermediate grades, middle grades 6-8, and 9-12th grades is one idea. In the high school grade level list make sure to list the subject area to be covered e.g., chemistry, physics.

4. *Topic Areas*
   This list will include ideas organized into a format based on broad scientific and mathematical themes. You may include all activities related to Energy, Magnets, Light, Sound, Alternative Energy, Weighing, Volume, General Education, Processes of Science, etc. All activities, regardless of the grade level, will be included in your theme listing. Remember to include the intended grade level. This format is a good method if you are unsure of what grade level an activity is appropriate for, or are interested in teaching a variety of subjects and grade levels. Many ideas could be used at several grade levels simply by adjusting the content up or down.

Requirements

During your internship, it is expected that you will be able to develop at least **one** integration idea per week. You should include as many details as possible so that when you develop the lessons in greater detail in your classroom, you have a useful outline to follow. Ideas to include in your journal might be: materials, objectives for students to attain, time allotted (one class period; ½ hour etc.), instructional methods, assessment ideas, etc. Even if you change these thoughts once you begin teaching, they will provide you with valuable information to ensure that your lab experience is relevant to your classroom instruction.

Integration Ideas

Below is a list of possible scientific processes that you may encounter at your lab which could be integrated in quality classroom lessons. These suggestions will help you understand what types of ideas should be included in your journal.

(Note to Laboratory Education Staff – For each of the ideas listed below, please provide an actual example, where appropriate, from your lab, of what this activity might look like. For example, in the teamwork section, your scientists might work with a team spread throughout the world and they have worked out methods for communication. Please include as many specific, concrete examples as you can so that the students understand what is expected in their journals.)

1. How scientists work – teamwork, working out differences in an agreeable way, and communicating with collaborators
2. Scientific labs workable in the classroom – list by topic area such as Chemistry, Physics, Earth Science
3. Computer use – technology – programming ideas – keyboarding
4. Conducting meetings – brainstorming – communication
5. Creating a lab notebook
6. Computer documentation of lab results and how scientists use computers
7. Math calculations and ways that scientists use mathematics including measurement, error documentation and statistics.
8. What happens when research doesn't work out the way that was expected? How do scientists take set backs and re-adjust so that even apparent failures can reveal important discoveries, and how can you use this information in your own classroom when your experiments appear to have failed?
9. Collecting data and recording results.
10. How do scientists learn new information – meetings, seminars, colloquia, etc.?
11. Simple early grade explorations that pertain to the complicated subject specific research at the lab, such as electromagnets, circuits and basic atomic structure, if you are involved in research at an accelerator facility. Try to take the concepts from your research or the design of the facility and digest them down to the basic elements that even an early elementary student could understand.

During your laboratory experience you will have experiences that can influence your future teaching. These ideas can be developed as ways of making teaching and learning more like doing science. These ideas can also be included into your journal in any format that will be of future use to you in your classroom.

Here is an example that actually occurred at one of our National Laboratories and illustrates how a future teacher used what happens when research does not go as expected within their teaching. He observed what research teams do when research doesn't go right. What can one learn from this experience to help your future students when their experiment doesn't work as they expect?

One high school teacher had a class whose experiment produced meaningless data. Ordinarily he would have gone right on the next day to the next lesson. However, because of his research experience, he realized that scientists would fix what went wrong before continuing with their research. He asked his students to discuss problems in their data, then redesign and repeat their experiment. They did, and the second time the students got good data.

Here's another example: a teacher changed his whole teaching approach so that now he tells his students he is the theorist and in this role introduces topics, explains concepts, etc. Students are the experimentalists who must design and conduct experiments to test his theories. In this way he has students coming up with and analyzing "research questions" instead of doing cookbook experiments.

As PST interns, try to look for ways scientists work and solve problems that can be translated to the classroom. The primary aim of this journal is to help you integrate these laboratory experiences into your future classroom. The above lists of organizational and integration ideas are only a brief set to get you started thinking about how to gain the maximum benefit from your lab experience.

PART 9: THE DIGITAL PORTFOLIO

This deliverable for Pre-Service Teachers may include any of the following elements that can be recorded in a digital format. This is only a partial list, so feel free to include any further items that would be useful to you in your future classroom.

1) A reflective journal
2) Lesson plans related to research at the lab (these could involve different types of activities, e.g. a field trip to the lab, use of technology, use of scientific data, science careers, an experiment, a hands-on, inquiry activity, etc.)
3) Observations of science lessons (Laboratory Science Teacher Professional Development (LSTPD) teachers, if available at your lab, or summer school) and subsequent analysis of the lessons
4) Videotape of microteaching (PST interns teaching 15 minute lessons to their peers)
5) A research paper on a science topic
6) A science teaching aid (e.g., a physical model, web site, computer software, demonstration, game, an online quiz, tutorial, etc.)
7) Attendance at scientific presentations/lectures followed by short articles describing what they have learned and how it might be applied in the classroom (these could even be submitted to an National Science Teachers Association (NSTA) journal for possible publication)

All of the above should be related to the scientific research that you are involved in at your lab. This digital portfolio is required to be uploaded via your eduLink account.

PART 10: DEPARTMENT OF ENERGY CONTACTS

DOE Headquarters-Office of Science

Office of Workforce Development for Teachers and Scientists
U. S. Department of Energy, SC-27
1000 Independence Avenue, SW
Washington, DC 20585
Fax: (202) 586-0019
http://www.scied.science.doe.gov

Peter Faletra, Director, Office of Workforce Development for Teachers and Scientists
Phone: (202) 586-6549
peter.faletra@science.doe.gov

Sue Ellen Walbridge, Program Manager (SULI, FaST)
Phone: (202) 586-7231
sue-ellen.walbridge@science.doe.gov

Cindy Musick, Program Manager (PST, CCI)
Phone: (202) 586-0987
cindy.musick@science.doe.gov

Brian O'Donnell, Program Manager
Phone: (202) 586-7399
brian.o'donnell@science.doe.gov

Ebony Sails, Program Analyst
Phone: (202) 586-9770
ebony.sails@science.doe.gov

Todd Clark, Science Education Advisor
Phone: (202) 586-7174
todd.clark@science.doe.gov

DOE National Laboratory Education Directors and Staff

Ames Laboratory

111 TASF
Ames, IA 50011-3020
Fax: (515) 294-3226
http://www.external.ameslab.gov

Steve Karsjen, Education Director
Phone: (515) 294-9557
karsjen@ameslab.gov

Argonne National Laboratory

Building 223 Room M125
9700 S. Cass Avenue
Argonne, IL 60439
Fax: (630) 252-3193
http://www.dep.anl.gov/

Harold Myron, Director, Division of Educational Programs
Phone: (630) 252-3380
hmyron@dep.anl.gov

Frank Vivio (SULI)
Phone: (630) 252-3376
fvivio@dep.anl.gov

Linda Phaire-Washington (CCI, FaST)
Phone : (630) 252.1751
lwashington@dep.anl.gov

Lou Harnisch (PST)
Phone: (630) 252-6925
lharnisch@dep.anl.gov

Brookhaven National Laboratory

Building 438
P. O. Box 5000
Upton, NY 11973-5000
Fax: (631) 344-5832
http://www.bnl.gov/scied/

Ken White, Manager, Office of Educational Programs
Phone: (631) 344-7171
kwwhite@bnl.gov

Melvyn Morris (SULI, PST)
Phone : (631) 344-5963
mmorris@bnl.gov

Noel Blackburn (FaST, CCI)
Phone: (631) 344-2890
blackburn@bnl.gov

Fermi National Accelerator Laboratory

Pine Street & Kirk Road
MS-226
Box 500
Batavia, IL 60510
Fax: (630) 840-8248
http://www-ed.fnal.gov/ed_home.html

Marjorie G. Bardeen, Manager, Education Office
Phone: (630) 840-2031
mbardeen@fnal.gov

Spencer Pasero (PST, SULI)
Phone: (630) 840-3076
spasero@fnal.gov

Idaho National Laboratory

P. O. Box 1625
Idaho Falls, ID 83415-3790
Fax: (208) 526-1880
http://education.inl.gov/

Una Tyng (SULI)
Phone: (208) 526-1626
una.tyng@inl.gov

Jeff Benson (PST)
Phone: (208) 526-3841
jeff.benson@inl.gov

Lawrence Berkeley National Laboratory

Center for Science and Engineering Education
MS 7R0222
Berkeley, CA 94720
Fax: (510) 486-4813
http://www.lbl.gov/Education/CSEE/index.html

Rollie Otto, Department Head
Center for Science and Engineering Education
Phone: (510) 486-5325
rjotto@lbl.gov

Laurel Egenberger, College and University Program
Center for Science and Engineering Education
Phone: (510) 486-5190
llegenberger@lbl.gov

Lawrence Livermore National Laboratory

Science and Technology Education Program
PO Box 808, L-418
7000 East Avenue
Livermore, CA 94550
Fax: (925) 422-5761
http://www.llnl.gov/urp/

Dick Farnsworth (CCI)
Phone: (925) 422-5059
farnsworth1@llnl.gov

Laura Gilliom, Director of University Relations
Phone: (925) 422-9553
gilliom1@llnl.gov

Los Alamos National Laboratory

STB-Education Program Office
TA-00, Bldg. 199, Room 157A/MS M700
Los Alamos, NM 87545
Fax: (505) 665-6871
http://www.lanl.gov/education/

David Foster, Manager, Education Programs
Phone: (505) 667-8680
foster_david_r@lanl.gov

National Renewable Energy Laboratory

Office of Education (Mail Stop 1713)
1617 Cole Blvd.
Golden, CO 80401-3393
Fax: (303) 275-3076
http://www.nrel.gov/education/

Cynthia Howell, Director, Office of Education
Phone: (303) 275-3010
cynthia_howell@nrel.gov

Linda Lung (SULI and CCI)
Phone: (303) 275-3044
linda_lung@nrel.gov

Matthew Kuhn (PST)
Phone: (303) 275-3688
matthew_kuhn@nrel.gov

Oak Ridge National Laboratory

Lee L. Riedinger
Phone: (865) 574-4321
riedingerl@ornl.gov

Oak Ridge Institute for Science and Education (ORISE)
P.O. Box 117, MS 36
Oak Ridge, TN 37831-0117
Fax: (865) 576-1609
http://www.orau.gov/orise.htm

Wayne Stevenson, Director
Science and Engineering Education
Phone: (865) 576-3283
Fax: (865) 241-5220
stevensw@orau.gov

Linda Holmes, Group Manager
Science and Engineering Education
Phone: (865) 576-3192
Fax: (865) 241-5219
holmesl@orau.gov

Martha Hammond (PST)
Phone: (865) 576-3425
hammondm@orau.gov

Pacific Northwest National Laboratory

Science & Engineering Education Programs
P.O. Box 999
Richland, WA 99352
Phone: (509) 375-2800
Fax: (509) 375-2576
http://science-ed.pnl.gov

Jeff Estes, Manager, Science Education Programs
Phone: (509) 375-2820
Jeff.Estes@pnl.gov

Royace Aikin (CCI and FaST)
Phone : (509) 375-6929
Royace.Aikin@pnl.gov

Karen Wieda (PST and SULI)
Phone: (509) 375-3811
kj.wieda@pnl.gov

Princeton Plasma Physics Laboratory

James Forrestal Campus
P. O. Box 451
Princeton, NJ 08543-0451
http://science-education.pppl.gov/

Andrew Post-Zwicker, Head of Science Education (PST)
Phone: (609) 243-2150
azwicker@pppl.gov

James Morgan (SULI)
Phone: (609) 243-2116
jmorgan@pppl.gov

Stanford Linear Accelerator Center

2575 Sand Hill Road
Mail Stop 81
Menlo Park, CA 94025
http://www.slac.stanford.edu/gen/edu/

Helen Quinn, Director (SULI)
Phone: (650) 926-2713
quinn@slac.stanford.edu

Thomas Jefferson National Accelerator Facility

12000 Jefferson Avenue, MS 16C
Newport News, VA 23606
Phone: (757) 269-7560
Fax: (757) 269-5065
http://education.jlab.org/

Jan Tyler, Science Education Director
Phone: (757) 269-7164
tyler@jlab.org

Stacy DeVeau (SULI, PST)
Phone: (757) 269-7560
stacy@jlab.org